ALLIGATOR BAYOU PONDING STUDY
PORT ARTHUR, TEXAS

PREPARED FOR:

CITY OF PORT ARTHUR

AND

JEFFERSON COUNTY DRAINAGE DISTRICT NO. 7

PREPARED BY:

VANSICKLE MICKELSON & KLEIN INC.

APRIL , 1990

VMK JOB NO. 467-05

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VANSICKLE · MICKELSON & KLEIN, INC.
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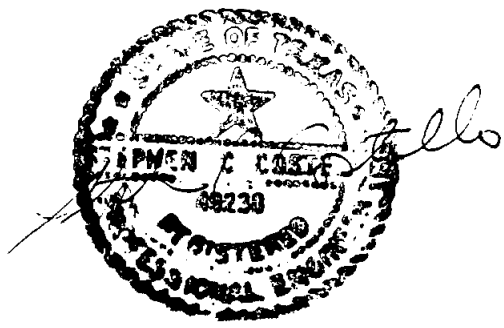
HOUSTON, TEXAS 77063



APRIL, 1990

VANSICKLE · MICKELSON & KLEIN · INC.

Stephen C. Costello, P.E.
Executive Vice President

April 9, 1990

Consulting Engineers

7500 San Felipe
Suite 700
Houston, Texas 77063

713-972-1220

City of Port Arthur
P. O. Box 1089
Port Arthur, Texas 77641

Attn: Mr. Ross Wilhite
Director of Planning

Re: Alligator Bayou Ponding Study
Port Arthur, Texas
VMK Job No. 467-05

Dear Mr. Wilhite:

We are pleased to submit the final report for the ponding study of the Alligator Bayou watershed. The report addresses the comments made by your office, Drainage District No. 7 and the Texas Water Development Board. We have provided 50 copies of the report as required by the contract and have forwarded 12 copies of the report to the Water Development Board and 2 copies of the report to Mr. Tom Hogan of Drainage District No. 7 as requested. We have also provided one set of hard copies of the computer models to each of the above recipients along with computer disks of the files.

We appreciate this opportunity to assist the City and the Drainage District in studying this challenging project. If we may be of further assistance, please call.

Sincerely yours,

VanSickle · Mickelson & Klein, Inc.

Stephen C. Costello, P.E.
Executive Vice President

SCC/GF/vc
EngRpt8

HOUSTON PROUD

EXECUTIVE SUMMARY

The purpose of this study was to determine several alternative methods of improvements to the Alligator Bayou drainage system to reclaim land from the 100-year ponding limits thereby permitting future development to occur within the watershed.

The study defined a method of analysis which utilizes (1) the sloped basin characteristics of the ponding area along Main "C" and (2) the conveyance and storage characteristics of the Main Outfall Channel more effectively than previous studies. The initial phase of this study was to re-establish the existing conditions 100-year flood plain within the Alligator Bayou watershed which would be utilized as the "no-action" alternative in this investigation, as shown on Exhibits 4 and 6. Once this base condition was defined, two methods of reclaiming land from the 100-year ponding limits were investigated.

Alternative 1 consists of investigating expansion of the Alligator Bayou Pump Station, with no improvements to the existing drainage channels within the system. This alternative would require an additional 2,250,000 gpm pumping capacity at an approximate cost of $39,000,000.00. Implementation of this alternative would reclaim approximately 1470 acres of land, as shown on Exhibit 4, or approximately $26,550/acre reclaimed.

Alternative 2 consists of investigating construction of several smaller pumping facilities strategically located within the ponding area combined with channel improvements. This alternative would require a pumping facility on Main "A" with approximately 704,000 gpm capacity and excavated detention storage of approximately 700 acre-feet in volume. An additional pumping facility is proposed along Main "C" which would

require a 883,000 gpm capacity pump station with a detention facility of approximately 1650 acre feet of storage volume and a levee system to protect the reclaimed area from backwater flooding from the main Alligator Bayou Pump Station. Channel improvements would be required along Main "B". The approximate cost of these improvements would be $40,585,000.00. Implementation of this alternative would reclaim approximately 3,285 acres of land, as shown on Exhibit 6, or approximately $12,355/acre reclaimed.

It is recommended that Alternative 2 be chosen as the method for reclaiming land in the Alligator Bayou watershed. The proposed improvements can be implemented in phases as development occurs and the larger area reclaimed by implementation of this alternative makes it more advantageous than other methods investigated.

In the course of this study, several inadequate bridge crossings were found to exist within the watershed (See Exhibit 6). Two of these crossings are located on Lateral "A-3" and are the causes of the overflows found to exist along Lateral "A-3". Improvement of these bridges could be implemented irrespective of any improvement alternative chosen and would remove approximately 1200 acres of land along this Lateral, approximately one-half of which is presently developed, from the existing 100-year flood plain limits as shown on Exhibit 6.

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

LIST OF FIGURES

LIST OF TABLES

LIST OF EXHIBITS

SECTION I

INTRODUCTION

A. AUTHORIZATION

On September 1, 1988, VanSickle • Mickelson & Klein, Inc., executed an agreement with the City of Port Arthur, Texas and Jefferson County Drainage District No. 7 to perform a hydrologic and hydraulic analysis of the Alligator Bayou watershed. This analysis was conducted under the direction of the City of Port Arthur, Director of Planning, and encompassed the area and streams which constitute the Alligator Bayou watershed.

B. PURPOSE AND SCOPE

The purpose of this study was to determine the existing limits of ponding caused by the occurrence of the 100-year frequency storm event within the Alligator Bayou watershed. This study included evaluation of several improvement alternatives which would minimize the ponding limits thereby allowing future development to occur within the watershed. Preliminary construction cost estimates of the alternatives investigated were developed. An environmental analysis is presented discussing wetlands areas, mitigation measures, etc. to aid in the application for a 404 permit from the U.S. Army Corps of Engineers. Alternatives for mitigation of the reclaimed areas are discussed in Appendix A and B. A land use plan for the reclaimed areas is presented based on the engineering and environmental considerations discussed in this text.

Due to the sensitive environmental conditions present within portions of the watershed, the U.S. Army Corps of Engineers and the Environmental Protection Agency will

review and approve the proposed alterations that may affect any wetlands areas found within the watershed.

C. ACKNOWLEDGEMENTS

This study was completed utilizing information from previous studies conducted by the U.S. Army Corps of Engineers and Turner, Collie & Braden, Inc.

VanSickle · Mickelson & Klein, Inc. gratefully acknowledges the cooperation of the staff of Jefferson County Drainage District No. 7 in providing information from District records and for the assistance in obtaining information from other local agencies. The cooperation of the management and staff of the cities of Port Arthur, Port Neches, Nederland and Groves is also appreciated.

SECTION II

GENERAL INFORMATION

A. LOCATION

The Alligator Bayou watershed is located in Jefferson County, Texas in and near the City of Port Arthur. Portions of the watershed also are within the boundaries of the cities of Groves, Nederland and Port Neches (see Exhibits 1 and 2). The watershed is located entirely within the Port Arthur Hurricane Flood Protection Levee System constructed by the U.S. Army Corps of Engineers for the purpose of providing flood protection to the City of Port Arthur and surrounding communities. The Alligator Bayou watershed is part of the levee protection system's interior drainage system and includes drainage channels conveying storm runoff to the Alligator Bayou Pump Station (P.S. #16), which pumps the runoff through the levee into Taylors Bayou. The entire levee system protects approximately 65 square miles of area, of which approximately 40 square miles (25,500 acres) comprises the Alligator Bayou watershed.

B. TOPOGRAPHY

The topography of the Alligator Bayou watershed is generally flat terrain with elevations in the southern portion of the watershed along the Main Outfall Channel (see Exhibit 2) ranging from +1 foot to +3 feet mean sea level (MSL). In the area of Main "C" between State Highway 365, State Highway 73 and U.S. Highway 69 the elevations range from below -1 foot to +2 feet MSL. Elevations in the northern portion of the watershed rise rapidly from +3 feet to above +15 feet MSL. These conditions create a very low area along Main "C" surrounded by relatively high areas. This low area has historically been a marshy

overflow area with the perimeter utilized for agricultural purposes. The higher regions have been mainly used for industrial, commercial and residential development with some areas used for ranching or agricultural purposes.

C. HISTORY

The Alligator Bayou watershed consists of three main drainage channels, Mains "A", "B" and "C" which are tributary to the Main Outfall Channel. The topography of the watershed, as previously discussed, created a natural semi-tidal detention area along the alignment of Main "C" thus promoting growth of a brackish marsh. Construction of the Hurricane Protection Levee System and the Alligator Bayou Pump Station effectively isolated this area from tidal influences, but the area still maintained its wetlands habitat potential due to its natural detention characteristics, the relatively high groundwater table and the large amount of yearly rainfall experienced in the region. This area has remained virtually undeveloped for the past 20 years due to its low elevations and the availability of alternate areas for development in the general vicinity.

The Alligator Bayou drainage system has been studied numerous times in the past. These studies have identified drainage requirements necessary to prevent flooding of the developed land located on the protected side of the hurricane protection system. Subsequent studies were completed to address flood control alternatives for the purpose of reclaiming land to permit future development. The previous studies utilized in this report are as follows:

1. U.S. CORPS OF ENGINEERS,
   DESIGN MEMORANDUM NO. 1B,
   APRIL, 1965

This study was completed in order to establish the design parameters for the Alligator

Bayou Pump Station and Gravity Outlet Structure. The study outlined the hydrologic conditions encountered within the watershed and recommended pump station and gravity outlet capacities to provide stormwater drainage to the land located on the protected side of the hurricane protection levee. The design tailwater in Taylors Bayou of +0.5 feet MSL used in the study assumed the gravity outlet structure would discharge the base flows and low flow runoff, with the pump station only operating during high tailwater conditions and extreme storm events. The Alligator Bayou Pump Station was subsequently designed and constructed in accordance with the recommendations of this study.

2. ALLIGATOR BAYOU WATERSHED STUDY, AUGUST 1981

This study was prepared by Turner, Collie & Braden, Inc. (TC&B) for the Jefferson County Drainage District No. 7 (Drainage District), to evaluate several improvement alternatives to the Alligator Bayou drainage system to reduce the area of ponding within the watershed. The proposed improvements included (1) maintaining a water level within the Alligator Bayou system of approximately -2.0 feet MSL, (2) providing an additional pump station facility with excavated storage upstream of the existing Alligator Bayou Pump Station and (3) construction of channel improvements to eliminate localized flooding in several upstream reaches of Mains "A", "B" & "C". Subsequently, the Drainage District submitted a request to the U.S. Army Corps of Engineers requesting permission to operate the Alligator Bayou Pump Station in such a manner as to maintain the -2.0 feet MSL water level within the watershed since this was a deviation from the original federal project parameters. No actions with respect to the other capital improvements were taken by the Drainage District.

3. OPERATION OF ALLIGATOR BAYOU PUMPING STATION, MAY 1984

This study was conducted by the U.S. Army Corps of Engineers to evaluate a request by the Drainage District to alter the operations of the Alligator Bayou Pump Station to

accommodate a lowered water level within the drainage system. The recommendation of this Corps of Engineer's study was to deny the Drainage District's request to lower the water level within the system due to the adverse effects this would have on the existing wetlands habitat areas within the watershed.

Another finding of this study was a deficiency in the performance of the gravity outlet structure at the Alligator Bayou Pump Station, causing the frequent use of the main pumps to discharge base flows and low flows. This deficient performance was due to the higher tailwater conditions experienced in Taylors Bayou than originally assumed in Design Memorandum No. 1B. The recommendation of this study was to install additional pumps at or near the existing Alligator Bayou Pump Station to discharge the base and low flows thereby alleviating the frequent use of the main pumps and reducing the maintenance required on the larger pumps. No actions in accordance with the above recommendations have been taken by the Drainage District.

D. SUBSIDENCE

The Alligator Bayou watershed, particularly the lower reaches of Main "C", has been acutely affected by subsidence in the past. This was due mainly to the removal of large amounts of natural gas and oil from below the area (Reference 2). This pumping also removed large amounts of groundwater in the process thus causing the area to subside at a fairly rapid rate. The reduction of pumping activities due to the depletion of the oil and gas reserves and the replenishment of the groundwater aquifer has led to a slowing of the rate of subsidence in the past 10-15 years. The Alligator Bayou Watershed Study, dated August 1981, indicated that no significant subsidence had occurred within the watershed from the period between 1976 -1981.

Field surveys were authorized in the initial development of this study. The primary purpose of the field surveys was to verify existing topographic maps prepared in 1976 that were to be used in the hydrologic and hydraulic analysis of the watershed (Section III). A survey was conducted by Soutex Surveyors, Inc. in October, 1988 within the lower reaches of Mains "B" and "C". The results of the survey indicated some slight elevation variations exist between the 1976 and 1981 surveys suggesting some subsidence had occurred since 1976. Thus, adjustments were made to the elevation contours shown as existing elevations on Exhibits 2-6 to reflect the elevations found in the Main "C" area by the Soutex survey. The surveyed elevations in the areas north of State Highway 365 and east of U.S. Highway 69 were found to match closely with the 1976 topograhic map. This would indicate that no significant subsidence has occurred in the middle and upper reaches of the Main "B" and Main "C" drainage areas.

E. SURVEY DATUM ADJUSTMENT

Soutex Surveyors, Inc. performed an elevation survey of several areas throughout the watershed. During the course of this survey, comparisons of several benchmarks established by various area agencies and the National Geodetic Survey were completed. It was found that for each of the benchmark series compared (i.e., Drainage District series, City of Port Arthur series, etc.), different datums had been previously utilized. Soutex Surveyors, Inc. recommended that in the future a common elevation datum be adopted by all area agencies to prevent further discrepancies and confusion when elevations are discussed. A copy of the Soutex report is included in the Appendix.

Based upon the Soutex report, a datum adjustment factor of -0.79 feet was applied to all Drainage District elevations for use in this study. This adjustment ensures that all elevations used in this study would be based on the same mean sea level elevations

established in the 1981 TC&B study, thereby complying with the recommendations of the 1988 Soutex Surveyors, Inc. report.

SECTION III

EXISTING CONDITIONS

The first phase of this study was to re-establish the existing conditions 100-year flood plain within the Alligator Bayou watershed. The existing conditions, as defined in the following sections will be utilized as the "no-action" alternative in order to evaluate the necessity and effectiveness of any proposed improvements. Determination of these flood limits would be through the use of three computer models developed by the U.S. Army Corps of Engineers. The input data for these computer models is described below.

A. HYDROLOGY

The U.S. Army Corps of Engineers "HEC-1 Flood Hydrograph Package" computer model was selected for this study. This computer model utilizes existing watershed characteristics (drainage area, rainfall, percent development, etc.) to study the rainfall-runoff relationship of a given watershed under investigation. The HEC-1 hydrology model for the existing Alligator Bayou watershed was developed with information obtained from several sources. The following paragraphs describe the watershed characteristics utilized in the hydrologic analysis. Table 1 lists the parameters for each subarea's characteristics.

RAINFALL - The rainfall distribution data was obtained from the 1965 Corps of Engineers, Design Memorandum No. 1B. The design event chosen was the 100-year frequency, 24-hour duration storm, which produces 15.04 inches of rainfall.

DRAINAGE AREAS - The drainage area delineations, shown on Exhibit 2, were obtained from the Drainage District's drainage area map. Several drainage areas were revised or updated with information obtained from the local industries and

municipalities. Subarea delineations were defined with the assistance of Drainage District staff.

BASE FLOW - Base flow conditions were established using information gathered from the local industries and municipalities. Also, the base flow contributed by groundwater exfiltration into the system was estimated from the Alligator Bayou pump station records from 1987 and 1988, provided by the Drainage District.

LOSS RATES - The initial rainfall loss and uniform rainfall loss rate parameters were obtained from the 1981 TC&B study (Reference 2). These parameters are shown in Figure 1. The percent of development within each subarea needed to define the above rainfall loss values were estimated using a November, 1987 aerial photograph of the watershed and from visual inspections of the drainage areas.

UNIT HYDROGRAPH PARAMETERS - The coefficients for the Snyder Unit Hydrographs used in this study are the lag coefficient (TP, in hours) and the peaking coefficient (CP). The lag coefficient is calculated using the formula $TP = C_t (L \times L_{ca})^{0.3}$. The coefficient C_t is a constant which is dependent on the shape, channel slopes and degree of development within a particular subarea. For the Alligator Bayou watershed these values range from 4.6, for 0 percent development, to 2.2, for 100 percent development conditions (See Figure 1). These values of C_t were obtained from the 1981 TC&B study. The length of the longest path (L) that rainfall will follow for a particular subarea and the length from the geometric centroid of the subarea L_{ca} to the downstream end point of the longest watercourse are determined from the drainage area map (Exhibit 2). The coefficient CP was also a constant which is dependent on the shape, channel

slope and degree of development within a watershed. For the Alligator Bayou watershed the value of CP was assumed to be constant and equal to 0.3125 as described in the 1981 TC&B study.

STORAGE-OUTFLOW - The storage values used in the hydrology model routing routines were obtained from multiple profile runs of the hydraulic models (HEC-2) of Mains "A", "B" and "C" and Main Outfall Channel. Various input flow values were chosen to give a resulting curve which covered the range of flows expected to occur for each particular reach through which routing would be simulated. The final HEC-2 storage models are shown in the Appendices.

PUMP STATIONS - Operation data for the various pump stations simulated in the hydrology model were obtained from the local industries and municipalities which own and operate the pump stations. Pump station data was also obtained for all Drainage District's pump stations within the watershed. Several pumps with similiar on/off elevations were combined within the model due to the limited number of pumps which could be simulated at any one station. These locations are noted in the HEC-1 computer model input data (as shown in the Appendices).

The HEC-1 pump station sub-routine was utilized for all of the upstream pump stations modelled in this study because the lack of pump station operation data precluded the use of the "Interior Drainage Flood Routing" program (see Paragraph B). The results of the HEC-1 pump routing routines used are adequate for the purposes of this study since these pump stations do not greatly affect the flood levels under investigation.

The HEC-1 computer models for this study were executed to calculate peak runoff values for each subarea within the watershed and to determine the total storm hydrograph for the entire watershed for subsequent use in the pump routing model. The computed 100-year frequency, 24-hour duration storm, peak flood flow for the entire watershed was 12,670 cubic feet per second (cfs). Peak flood flows at various locations throughout the Alligator Bayou watershed are shown in Table 2.

B. PUMP ROUTING

The pump routing program, "Interior Drainage Flood Routing" developed by the U.S. Army Corps of Engineers was utilized to simulate the operations of the Alligator Bayou Pump Station. This program enables routing of a flood hydrograph through the interior ponding area and main Alligator Bayou Pump Station to determine pump station outflow into Taylors Bayou and ponding elevations upstream of the pump station. The following paragraphs describe the input data to the model.

INFLOW FLOOD HYDROGRAPH - The input flood hydrograph was obtained directly from the HEC-1 computer model of the entire Alligator Bayou watershed. A tabulation of peak runoff versus time is included as part of the final hydrology model (see Appendix).

INTERIOR STORAGE - To determine the available storage in the existing ponding area for use in the pump routing, a rating curve (Figure 2) of elevation versus storage was developed. Utilizing the topographic map of the watershed, available overbank storage was calculated for flood elevations between -2.0 and +5.0 feet MSL. In addition to the overbank storage, channel storage within the Main Outfall Channel was included in the final rating curve. This storage was considered since the Main Outfall Channel is the direct connection between the

Alligator Bayou Pump Station fore bay and the primary ponding storage area. It was asssumed that no storage was available below elevation -2.0 since the current operation manual of the Alligator Bayou Pump Station precludes the Drainage District from lowering the existing ponding elevation below -2.0. Shown on Table 3 is a tabulation of the rating curve data that is also graphically shown on Figure 2. The final storage analysis of the Main Outfall Channel is included in the Appendix.

TAILWATER CONDITIONS - The pump routing model utilizes the outfall stream elevation as the tailwater elevation to calculate the gravity outlet structure discharge. The 1984 U.S. Army Corps of Engineers study (Reference 3) determined that the existing gravity outlet structure at the Alligator Bayou Pump Station does not discharge runoff flows into Taylors Bayou as intended. This deficiency in peformance is due to the higher average tailwater elevation of +2.7 feet MSL, than the +0.5 foot MSL elevation used in Design Memorandum No. 1B (Reference 1). Thus, all discharges from the interior storage pond into Taylors Bayou will be through the Alligator Bayou Pump Station pumps.

PUMP CAPACITY - The pump routing model utilizes a pump rating curve of pump capacity versus storage pond elevation, to calculate discharges from the system. The pump capacity of the Alligator Bayou Pump Station is dependent on the difference in tailwater elevation and storage pond elevation (pool-to-pool head) plus the amount of head losses along the Main Outfall Channel generated by the discharge flows of the pump station.

All of the previous studies completed on the Alligator Bayou watershed assumed the storage pond to be a level pool located immediately adjacent to the Alligator

Bayou Pump Station. The actual site conditions show the storage pond area operates as a sloped basin and the largest portion of the storage pond area is located along Mains "B" and "C", south of State Highway 365 and west of U.S. Highway 69, approximately 22,400 feet upstream of the pump station along the Main Outfall Channel alignment. The large distance from the pump station to the storage pond causes significant head losses to occur along the Main Outfall Channel, for the flows discharged by the Alligator Bayou Pump Station. These losses were calculated by HEC-2 analyses, shown in the Appendices, and are tabulated in Table 4 and shown graphically in Figure 3.

Shown on Figure 4 is the original pump rating curve for the Alligator Bayou Pump Station pumps as provided to the Drainage District by Systems Engineering Associates Corp. from 20-inch scale model tests of the pumps. Table 5 is a tabulation of pool-to-pool head, channel head losses and pump discharge capacities for several starting conditions and pump combinations. This table was prepared utilizing the data shown on Figure 4 plus the head losses in the Main Outfall Channel to illustrate the assumed reduction in pump capacity caused by the hydraulic head losses in the Main Outfall Channel. For all pump routing simulations of the Alligator Bayou Pump Station pumps, it is assumed the pumps will be operated at an engine speed of 800 RPM.

The pump routing model was executed to calculate beginning tailwater elevations for input into the HEC-2 hydraulic models of Mains "A" and "B". Various starting conditions at the Alligator Bayou Pump Station were run to observe the effects of these conditions on the calculated tailwater elevations. Table 6 lists the calculated tailwater elevations for use in the hydraulic study of Mains "A", "B" and "C".

C. HYDRAULICS

The U.S. Army Corps of Engineers "HEC-2 Water Surface Profiles Package" computer model was utilized to compute the water surface elevations throughout each stream within the Alligator Bayou watershed under investigation. This computer model utilizes cross-sectional data of each stream and obstruction (bridges and culverts), flood flows derived from the HEC-1 analysis and starting conditions from the existing pump station to calculate flood elevations throughout each stream. The HEC-2 hydraulic models for the existing Main Outfall Channel and Mains "A", "B" and "C" were obtained from the 1981 Turner, Collie & Braden study (Reference 2). Several additional bridges and additional stream cross-section data obtained from as-built information and drawings provided by Drainage District were added to the existing models. Cross section layout of the input data to the HEC-2 models is shown on Exhibit 3.

Specific revisions to the existing HEC-2 models include the additional cross-section data added to the Main "A" model, upstream of the State Highway 366 crossing to the headwaters of Main "A". Lateral "A-3" and sub-lateral "A-3-A" tributaries were added to the Main "A" model at the request of the Drainage District in order to verify observed flooding that has occurred along the upper reaches of these streams from previous storms. Additional cross-section data was added to the Main "B" model from the confluence of Lateral "B-3" upstream to the headwaters of Main "B". Cross-section data was also added to the Main "C" model from the U.S. Highway 69 crossing to the headwaters of Main "C". In addition, new cross-section data was prepared for the entire length of the Airport-Viterbo Ditch, a tributary of Main "C" and added to that model.

The HEC-2 models for Mains "A", "B" and "C" and their tributaries were executed to determine the water surface profiles along each of these channels as shown on Exhibits 7 -

14. These profiles were also used to delineate the limits of ponding caused by the 100-year frequency, 24-hour duration storm as shown on Exhibits 4 and 6.

Based upon a review of the hydraulic results, it was observed that along the reach of Main "A", between State Highway 73 and State Highway 347 and the reach of Main "B", between U.S. Highway 69 and Lateral "B-4" (see Exhibit 4) basin overflow occurs. Specifically, the overflow occurs in the area between Lake Arthur Drive and 60th Street, to the east of 9th Avenue when the water surface elevations exceed +3 feet MSL. In addition, several areas of overbank flooding occur upstream of the primary ponding area specifically due to inadequate structures (drop structures or bridges).

D. MODEL CALIBRATION

The existing condition HEC-1 model, pump routing model and HEC-2 models of Mains "A", "B" and "C" were calibrated using recorded rainfall data gathered during Tropical Storm "Claudette" which occurred July 24 - 27, 1979. Also observed during this storm event was a high water mark on the State Highway 365 bridge over Main "C". The elevation of this high water mark, after taking into account the previously discussed datum adjustment, was approximately +3.58 feet MSL.

The observed rainfall data was entered into the existing condition HEC-1 model. It was assumed that no changes in the development conditions occurred from the year 1979 to the present. The resulting calculated flood hydrograph for the entire watershed was then entered into the pump routing model prepared for the existing condition analysis. The pump routing model was executed and the resulting water surface elevation was entered into the existing HEC-2 models of Mains "A", "B" and "C" as the tailwater elevation for each stream.

These backwater models were then executed to calculate the water surface profiles resulting from the occurrence of the tropical storm event.

The computed water surface elevation in Main "C" at the crossing of State Highway 365 was calculated as +2.3 feet MSL. This was compared to the observed high water mark of +3.58 feet which yields a difference of 1.28 feet. This difference in computed versus observed water surface elevations could be attributed to the actual operations of the Alligator Bayou Pump Station during the storm event investigated. During the observed storm event, it became necessary for the pump discharge gates at the Alligator Bayou Pump Station to be closed due to the high tailwater conditions expected to occur in Taylors Bayou. This closure could be expected to reduce the pumping capacity, the magnitude of which would be very difficult to determine due to the lack of performance data on the pump station under these conditions. Consequently, higher water surface conditions than those calculated in this calibration process could be expected to occur within the drainage system.

Calibration of these models would be better facilitated if more high water mark observations were available, additional rainfall data was collected at various locations throughout the watershed, and actual performance records of the pump station were compiled. However, based upon the results of this calibration analysis, it appears that the computer models developed to simulate the drainage patterns within the watershed adequately represent existing drainage conditions.

E. RESULTS

As discussed above, the existing condition investigation delineated the 100-year frequency ponding as shown on Exhibits 4 and 6. Should no improvements to the Alligator Bayou drainage system be undertaken, these flooding conditions would persist and flooding

of the presently developed areas along Mains "A" and "B", upstream of U.S. Highway 69 would continue to occur. No improvements to the drainage system would allow the ponding area along Main "C" to continue to function as a wetlands habitat as described in the environmental assessment (Appendix A).

FIGURE 1
INITIAL LOSS, INFILTRATION AND C_t

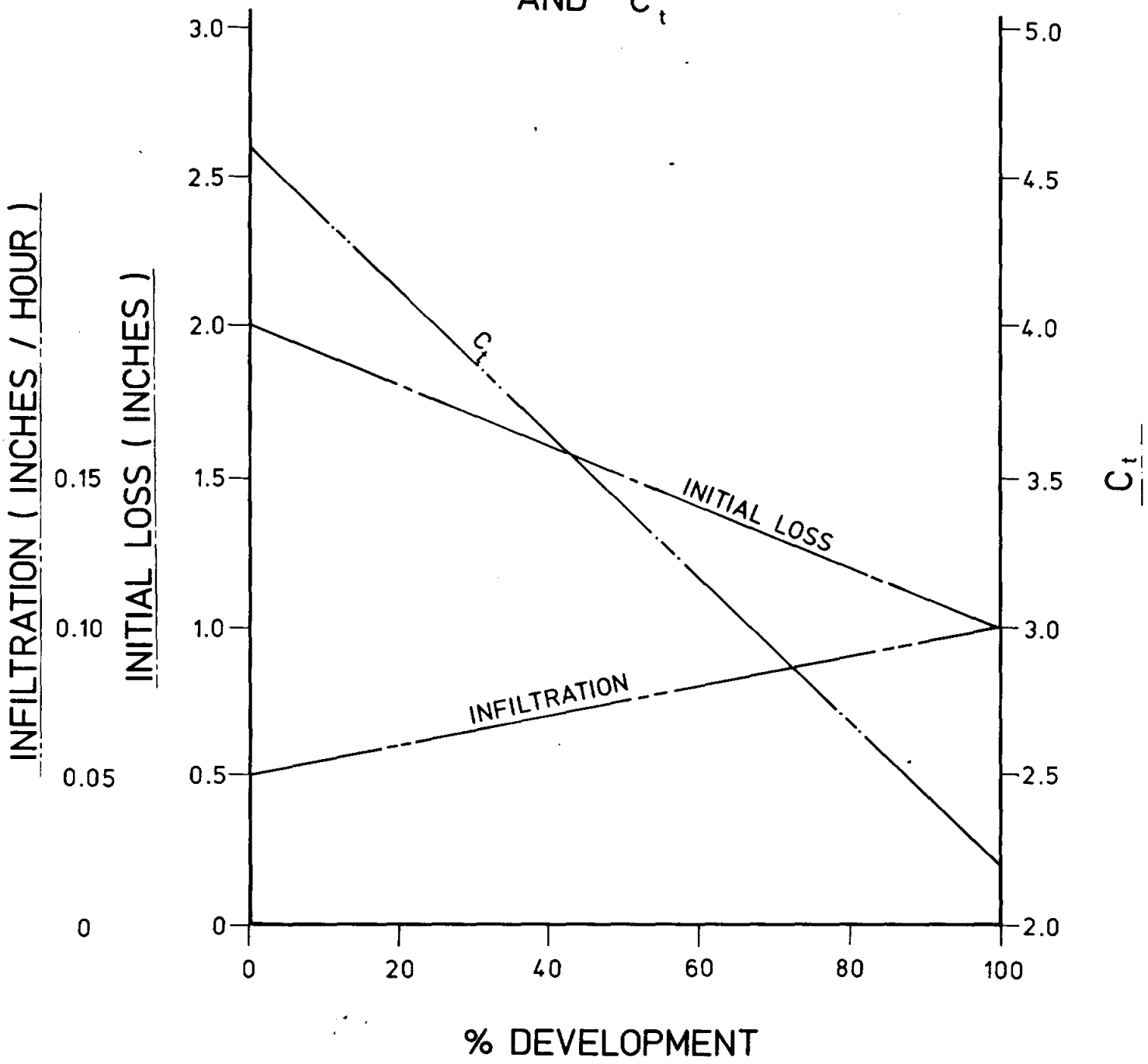


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FIGURE 2
POND ELEVATION vs CUMULATIVE STORAGE
RATING CURVE

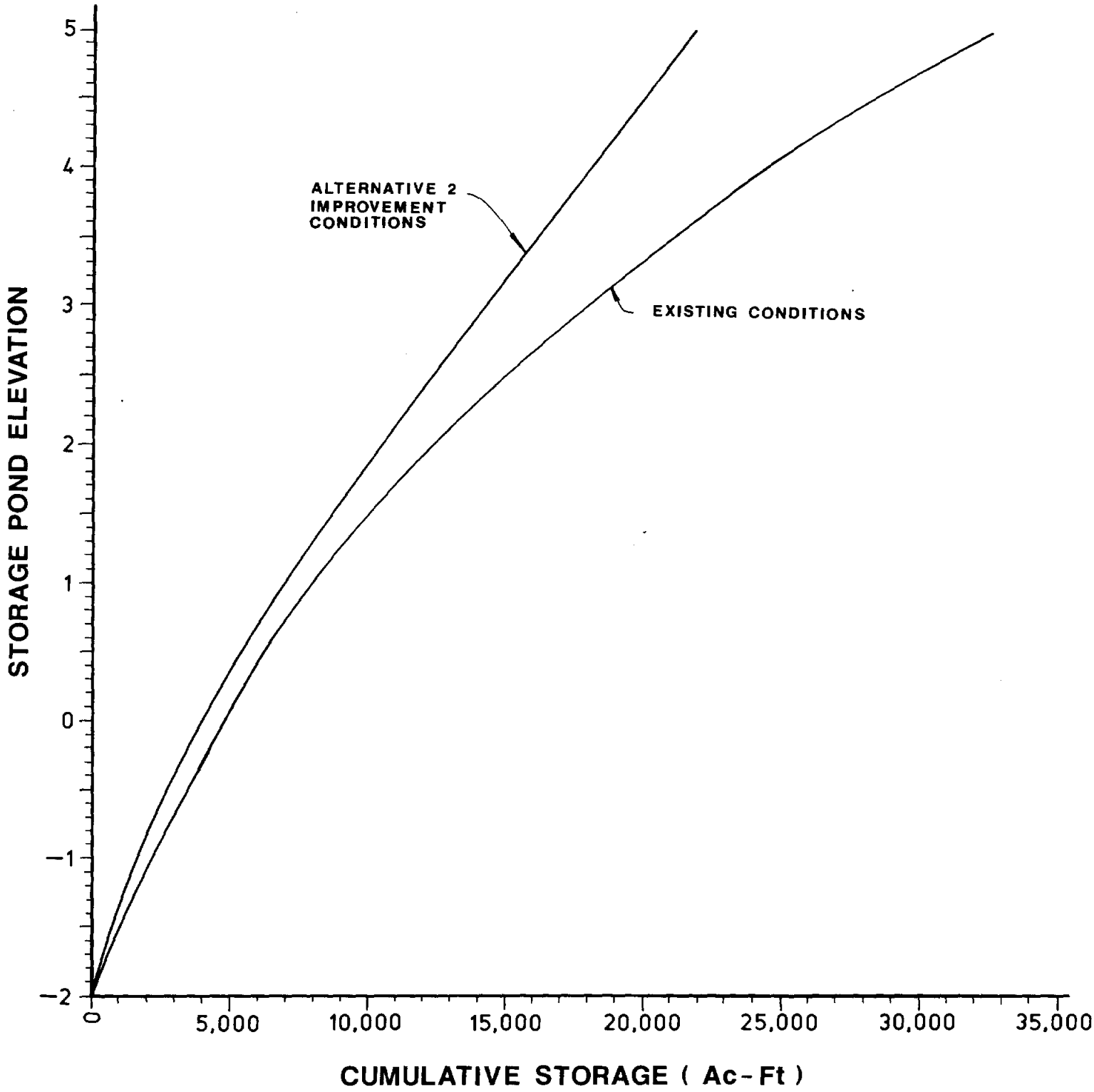

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FIGURE 3

MAIN OUTFALL CHANNEL HEAD LOSSES

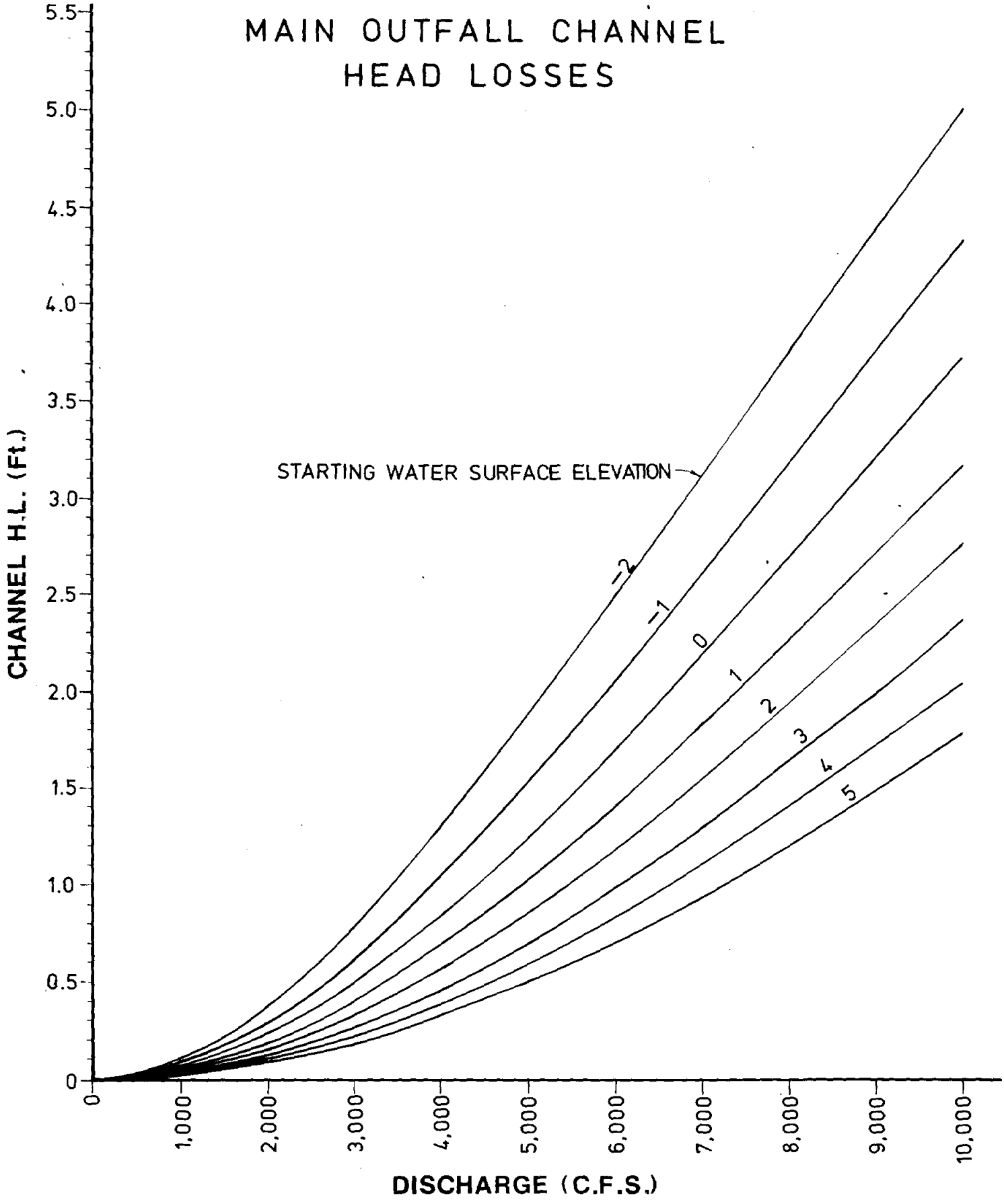

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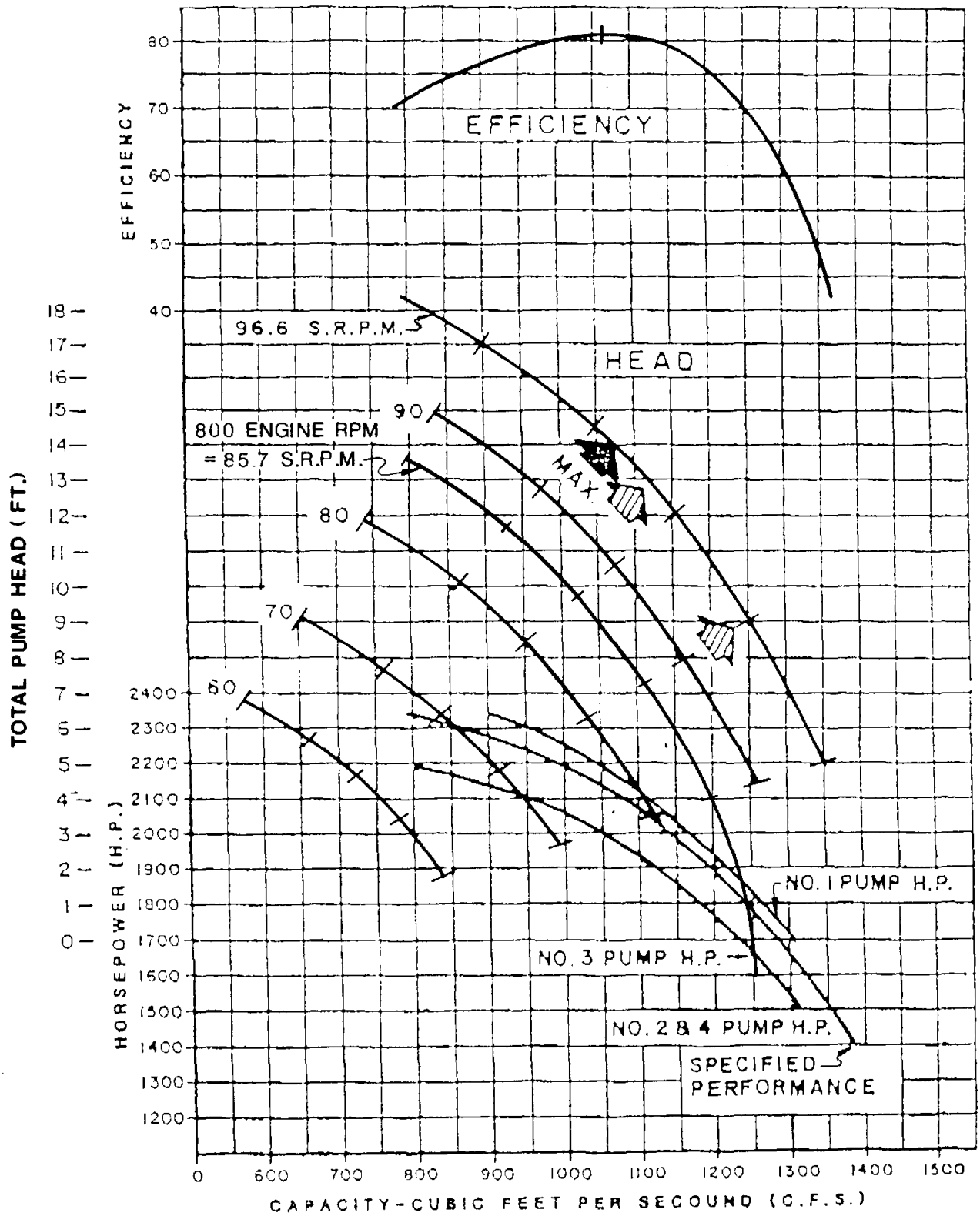
FIGURE 4

144"-6320 PUMP
96.58 RPM
BASED ON 1/7.32
MODEL TESTS
SUCTION 0.0 EL.

ALLIGATOR BAYOU PUMPING STATION

PUMP RATING CURVE (SINGLE PUMP)



SYSTEMS ENGINEERING ASSOCIATES CORP.

ENC. FIVE

SHEET ONE OF ONE

JANUARY, 1986

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implementation. The existing development conditions were used in this alternative to establish a basis of comparison for further investigation of the alternatives.

A. HYDROLOGY

For this pumping alternative, no changes to the hydrologic characteristics of the watershed were investigated. The existing development conditions and routing parameters were used to observe the effects of the increased pumping capacity on the existing ponding limits.

B. PUMP ROUTING

For this pumping alternative, increasing the pumping capacity of the Alligator Bayou Pump Station was investigated. The inflow hydrograph calculated in the existing conditions analysis was used (see Appendix). Increased pumping capacity was added by assuming additional pumps of the same size and capacity as the existing pumps. Analyses adding from 1 to 4 additional pumps with varying starting water surface elevations were investigated. The results of each analysis were compared to determine the optimum amount of additional pumping capacity for the Alligator Bayou System. The results of adding 4 pumps to the Alligator Bayou Pump Station capacity were chosen as the starting conditions for the backwater calculations along Mains "A" and "B" to determine the maximum reduction of the ponding limits for this alternative. The beginning tailwater elevations used are listed in Table 6.

C. HYDRAULICS

As discussed above, the peak flows for use in the backwater analyses (See Table 2)

were obtained from the existing conditions HEC-1 analysis. The beginning tailwater elevations (See Table 6) for Mains "A" and "B" were taken from the pump routing model simulating the pump station with 4 additional pumps. With these parameters and the appropriate tailwater elevation input for the Main "C" model, the resulting ponding limits were determined as shown on Exhibit 4.

D. RESULTS

The results of the addition of four 562,500 gpm pumps to the Alligator Bayou Pump Station, under existing runoff characteristics with no proposed channel improvements, is to reclaim approximately 1470 acres for development from the 100-year ponding limits within the watershed. The total cost of these improvements would be approximately $39,000,000.00 or $26,550.00 per acre reclaimed as shown in Section V of this text. Table 8 lists the amount of area reclaimed to the east and west of U.S. Highway 69 by this alternative.

Due to development pressures within certain portions of the watershed, particularly those areas presently affected by the existing ponding limits, this proposed alternative was considered to be infeasible because of the limited amount of area reclaimed. These reclaimed areas are also limited in development potential due to their location and limited accessibility to major traffic corridors. For these reasons, no further investigation of this alternative was performed.

ALTERNATIVE 2

The second alternative investigated to reduce ponding limits within the study area consisted of construction of a detention/pumping facility on Main "A" upstream of the 9th

Avenue crossing, construction of channel improvements along Main "B" from Sta. 59+00 to Sta. 187+00, and construction of a detention/pumping facility on Main "C" to the east of the existing Montrose Addition Subdivision as shown on Exhibit 5. No other improvements are proposed. In addition, the Alligator Bayou Pump Station will be operated within the guidelines of the Operation and Maintenance Manual (Reference 4). This alternative first used the existing development conditions for the watershed to observe the effect of the proposed improvements on the existing ponding limits. The results were compared to the results from Alternative 1 and it was determined the projected development conditions for the watershed should be used to investigate the future ponding limits created by the proposed improvements. Future development was selected for analysis because increased development will result in increased runoff thereby possibly changing the computed ponding limits within the watershed.

A. HYDROLOGY

The estimated 20-year development conditions of the watershed were used to investigate this proposed alternative. Several routings and drainage areas were changed to reflect the proposed detention/pumping facilities. These changes were made to the drainage areas along the lower reaches of Main "A" and the reaches of Main "C" from south of State Highway 365 to U.S. Highway 69. The proposed drainage areas are shown on Exhibit 5 and the developed conditions runoff parameters are listed in Table 7.

The Main "A" proposed detention facility would be located upstream of the 9th Avenue crossing and would require 700 acre-feet of storage volume which could be provided by a detention pond of approximately 110 acres of surface area to be excavated to elevation -4.0 feet MSL. This detention facility would provide sufficient storage capacity for the proposed

704,000 gpm pump station to maintain a beginning tailwater elevation of +1.6 feet MSL for the upper reaches of Main "A".

The Main "C" proposed detention facility would be located adjacent to the existing Montrose Addition Subdivision levee south of State Highway 365 along Main "C". The detention facility would require 1650 acre-feet of storage volume which could be provided by a detention pond of approximately 275 acres of surface area to be excavated to elevation -4.0 feet MSL and would provide sufficient storage capacity for the proposed 883,000 gpm pump station to maintain a beginning tailwater elevation of +1.0 feet MSL for the upper reaches of Main "C".

The HEC-1 pump routing option was used to simulate the proposed pump stations described above since more detailed information on the proposed pump stations can not be determined in this study, which precludes the use of the "Interior Drainage Flood Routing" model. However, the HEC-1 pump station routing routines will provide beginning tailwater elevations for the HEC-2 models of the upstream reaches of Mains "A" and "C". The HEC-1 model for this proposed alternative calculates a 100-year frequency, 24-hour duration storm runoff peak flow, of 12,740 cfs for the entire watershed. Peak flood flows at various locations throughout the Alligator Bayou watershed are shown in Table 2.

B. PUMP ROUTING

The pump routing model for the existing Alligator Bayou Pump Station was executed using the inflow hydrograph for projected development conditions calculated as described above to obtain beginning tailwater elevations for backwater analyses of Main "B" and the revised lower reach of Main "A". The resulting beginning tailwater elevations used are listed in Table 6.

Due to the revised routings used in the HEC-1 model for this alternative, the storage pond elevation versus cumulative storage values were adjusted in the pump routing model. The revised storage values, shown in Table 3, reflect storage available only in those areas where ponding is shown to occur in Exhibit 6. Figure 2 shows graphically the elevation versus storage curve for this alternative.

C. HYDRAULICS

The existing condition HEC-2 models of Mains "A", "B" and "C" were revised to reflect the changes in the drainage area and routing configurations. These changes included separating the lower and upper reaches of Mains "A" and "C", respectively, with levees and detention facilities (See Appendix), and channel improvements to Main "B". No other channel improvements are proposed for Mains "A" and "C".

The Main "B" proposed channel improvements include lowering of the channel flowline from Station 59+00 to Station 187+00, with a minimum proposed bottom width of 45 feet (Exhibit 5). These improvements are proposed to remove a rise in the existing channel flowline between Station 140+00 and Station 187+00 and also to widen the channel bottom in this reach (See Exhibit 11). For the reach between Station 59+00 and Station 140+00 the purpose of these improvements is to remove the accumulated silt from the existing channel bottom.

The backwater analyses of the upper reaches of Main "A" and "C" will be dependent on the beginning water surface elevations calculated by the respective HEC-1 pump routing routines of the proposed pump stations. The backwater analyses of the lower reaches of Mains "A" and "C" and the entire Main "B" system will remain dependent on the beginning water surface elevations calculated by the Alligator Bayou Pump Station pump routing

model. The beginning water surface elevations used are listed in Table 6. The calculated water surface profile of each channel is shown on Exhibits 7-14.

D. RESULTS

The results of the above described proposed channel improvements and proposed detention/pumping facilities are to remove approximately 3285 acres from the 100-year ponding limits. The implementation of the proposed 704,000 gpm pumping facility and 700 acre-feet volume detention facility along Main "A" and the proposed channel improvements along Main "B" will eliminate the basin overflow that presently exists under existing conditions. This separation of basins will allow each channel system to operate independently and thus all of the land between the two channels to the east of U.S. Highway 69 can be reclaimed for future development.

The implementation of the proposed 883,000 gpm pumping facility and 1650 acre-feet volume detention facility along Main "C" will allow all of the area to the north of State Highway 365 and a large parcel of land along the south side of State Highway 365 and the west side of U.S. Highway 69 to be removed from the 100-year ponding limits and thus be reclaimed for future development. These areas are shown on Exhibits 5 and 6. Table 8 lists the amount of area reclaimed to the east and west of U.S. Highway 69 by this alternative.

Since each channel system was investigated independently, and the upper reaches of Main "A" and "C" will be controlled by the new interior pumping facilities, it appears that this alternative could be implemented in phases. As development occurs within the watershed and funding becomes available, phased construction of the improvements to meet the needs of future development is possible.

The total costs of these improvements would be approximately $40,585,000.00 or $12,355.00 per acre reclaimed, as shown in Section V of this text.

Soils investigations should be performed on the locations of the proposed detention/pumping facilities to verify conditions are adequate to support the excavations required for the detention facilities.

In the course of this study, several inadequate bridge crossings were found to exist within the watershed (See Exhibit 6). Two of these crossings are located on Lateral "A-3" and are the causes of the overflows found to exist along Lateral "A-3". Improvement of these bridges could be implemented irrespective of any improvement alternative chosen and would remove approximately 1200 acres of land along this Lateral, approximately one-half of which is presently developed, from the existing 100-year flood plain limits as shown on Exhibit 6.

SECTION V

PRELIMINARY CONSTRUCTION COST ESTIMATES

Below are preliminary construction cost estimates for the two proposed alternatives for improvement of the Alligator Bayou drainage system. The unit prices are based on current bid quotations from similar projects in the Houston area and are based on 1989 dollars. These cost estimates include all items necessary for construction plus engineering fees for design of the improvements and contingency amounts calculated as a percentage of the construction costs. Annual maintenance and operation costs were provided by the Drainage District and are based on average yearly costs of similar facilities presently operated by the Drainage District. These estimates do not include costs associated with acquisition of land for rights-of-way or easements or surveying, legal and administrative fees. It is assumed that the rights-of-way necessary for construction of the proposed improvements will be donated by the adjacent land owners as compensation for reclamation of property from the 100-year flood plain.

ALTERNATIVE I

ITEM	UNIT	QUANTITY	UNIT PRICE	PRICE
Additional Pump Capacity including Appurtenances	GPM	2,250,000	$ 15.00	$ 33,750,000.00
			15% Engineering and Contingencies	5,250,000.00
			GRAND TOTAL	$ 39,000,000.00
Annual Maintenance and Operation Cost				
Alligator Bayou Pump Station Expansion	YR	1	$200,000.00	$ 200,000.00

ALTERNATIVE 2

ITEM	UNIT	QUANTITY	UNIT PRICE	PRICE*
MAIN "A"				
Detention Pond Construction	CY	1,250,000	$ 3.00	$ 3,750,000.00
Pump Station including Appurtenances	GPM	704,000	15.00	10,560,000.00
			SUBTOTAL	$ 14,310,000.00
MAIN "B"				
Channel Excavation	CY	270,000	$ 3.00	$ 810,000.00
Seeding & Fertilizing Channel Slopes	AC	45	$ 1,000.00	45,000.00
			SUBTOTAL	$ 855,000.00
MAIN "C"				
Detention Pond Construction	CY	2,225,000	$ 3.00	$ 6,675,000.00
Levee Construction	CY	40,000	$ 5.00	200,000.00
Pump Station Including Appurtenances	GPM	883,000	$ 15.00	13,245,000.00
			SUBTOTAL	$ 20,120,000.00
			TOTAL	$ 35,285,000.00
			15% Engineering & Contingencies	5,300,000.00
			GRAND TOTAL	$ 40,585,000.00
Annual Maintenance and Operating Cost				
Main "A" Pump Station	YR	1	$ 55,000.00	$ 55,000.00
Main "C" Pump Station	YR	1	$ 70,000.00	$ 70,000.00

*The above preliminary cost estimates do not include the costs of acquisition of the necessary right-of-way for construction of the proposed detention or pumping facilities. It is assumed that this right-of-way would be donated by the adjacent land owners as compensation for reclamation of property from the 100-year flood plain.

SECTION VI

RECOMMENDATIONS

The results of the alternatives investigated for reclaiming land from the 100-year ponding limits in the Alligator Bayou watershed indicate that Alternative 2, proposed detention/pumping facilities and channel improvements, is the recommended method for reclaiming land in this area. Implementation of Alternative 2 reclaims approximately 3285 acres of land, approximately two times the amount reclaimed by Alternative 1. Alternative 2 also has the advantage of being constructed in phases as development occurs or as the funding for the improvements becomes available.

This alternative also appears to have less impact on the environmental characteristics of the lower portion of the Main "C" drainage area, which has been a point of concern for the U.S. Army Corps of Engineers and other state and federal agencies. To facilitate implementation of this alternative, the City of Port Arthur and the Drainage District should further investigate the specific locations and design parameters for the proposed detention/pumping facilities and submit applications to the proper agencies for approval of implementation of these improvements.

SECTION VII

TABLES

TABLE 1
HEC-1 INPUT VARIABLES
(Existing Conditions)

Drainage Area	Name	Area (Ac)	Dev. (%)	Base Flow(cfs)	Initial Loss(in.)	Infiltration (in/hr)	L (ft)	L_{ca} (ft)	C_t	TP (hr)
5A	UPPERC	1455	100	3.32	1.00	0.10	19,800	9400	2.20	3.89
5B	AIRPORT	1104	75	0	1.25	0.0875	14,600	8800	2.80	4.43
26	MONT	351	75	0	1.25	0.0875	7,200	3700	2.80	2.76
8	PS3	455	50	0	1.50	0.075	6,200	1100	3.40	2.23
5C	MIDC	3392	10	8.14	1.90	0.055	21,200	6700	4.35	7.09
5D	LOWC	2070	0	9.94	2.00	0.05	17,000	5700	4.60	6.68
6A	UPPERB	2951	100	0	1.00	0.10	19,800	8100	2.20	3.72
6B	LOWB	1252	10	6.01	1.90	0.055	15,200	6700	4.36	6.43
9A	UPPERA	1673	100	4.02	1.00	0.10	19,800	8400	2.20	3.76
9B	A-3	1250	50	6.44	1.50	0.075	13,900	5800	3.40	4.68
9C	LOWA	1021	20	3.68	1.80	0.060	19,000	9500	4.12	7.22
12	PEAR	3654	80	0	1.20	0.090	19,100	6600	2.68	4.22
27D	SPOIL	455	0	2.18	2.00	0.050	8,400	3000	4.60	4.47
25	VISTA	122	20	0	1.80	0.060	5,200	2700	4.12	3.35
24	PS2	1013	75	0	1.25	0.0875	9,700	3700	2.80	3.02
27B	TEXCHE	129	75	0	1.25	0.0875	4,000	1000	2.80	1.59
27C	TEXRES	51	50	0	1.50	0.075	3,300	2000	3.40	2.21
14	CENT	1903	100	0	1.00	0.10	13,500	4900	2.20	2.85
27A	IND	1111	0	42.27	2.00	0.05	13,200	3900	4.60	5.53
		25,412		86.00						

TABLE 2
100 PEAK FLOOD FLOWS
FOR HEC-2 MODELS

Station	Existing Condition Flow (cfs)	Future Condition Flow (cfs)
MAIN "A"		
0+00	4975	4540
30+70	3735	3300
83+00	2495	2060
101+80	-	1570
123+00	2260	-
131+80	-	2670
174+30	2130	2395
202+00	1310	1310
240+00	840	840
267+00	500	500
271+15	450	450
306+40	65	65

Station	Existing Condition Flow (cfs)	Future Condition Flow (cfs)
LATERAL "A-3"		
0+00	820	1090
34+00	480	635
LATERAL "A-3-A"		
0+00	240	320
31+65	120	160
MAIN "B"		
0+00	4740	5005
59+00	2890	3385
134+50	2315	2315
155+00	2020	2020
190+82	1500	1500
197+85	1400	1400
233+00	895	895
255+70	565	565
269+45	370	370
283+20	170	170

TABLE 2
100 PEAK FLOOD FLOWS
FOR HEC-2 MODELS
(CONT'D)

Station	Existing Condition Flow (cfs)	Future Condition Flow (cfs)
MAIN "C"		
0+00	3330	2940
95+30	-	2345
123+20	-	2125
138+90	3425	4095
201+60	1900	1990
228+20	1130	1130
235+05	975	975
273+65	815	815
294+75	670	670
308+40	575	575
319+75	495	495
350+25	290	290
352+25	270	270

Station	Existing Condition Flow (cfs)	Future Condition Flow (cfs)
AIRPORT-VITERBO DITCH		
0+50	770	860
55+35	400	450
69+00	285	320
80+35	205	225
95+55	95	105

TABLE 3

PONDING AREA STORAGE DATA

ELEV. (FT)	AREA (AC)	INCREMENTAL STORAGE			CUMULATIVE STORAGE (AC-FT)
		OVERBANK STORAGE (AC-FT)	CHANNEL STORAGE (AC-FT)	TOTAL STORAGE (AC-FT)	
EXISTING CONDITIONS					
-2	1842	0	0	0	0
-1	2210	2026	186	2212	2,212
0	2678	2444	190	2634	4,846
1	3318	2998	288	3286	8,132
2	4221	3770	388	4158	12,290
3	6113	5167	491	5658	17,948
4	5377	5745	597	6342	24,290
5	9271	7324	707	8031	32,321
PROPOSED ALTERNATIVE 2					
-2	1250	0	0	0	0
-1	1665	1460	95	1555	1,555
0	2620	2145	190	2335	3,890
1	3070	2845	290	3135	7,025
2	3215	3145	390	3535	10,560
3	3250	3235	490	3725	14,285
4	3250	3250	595	3845	18,130
5	3250	3250	705	3955	22,085

TABLE 4

MAIN OUTFALL CHANNEL HEAD LOSSES
(in Feet)

Q (cfs)	STARTING WATER SURFACE ELEVATION							
	-2'	-1'	0'	+1'	+2'	+3'	+4'	+5'
1,000	0.10	0.07	0.06	0.05	0.04	0.03	0.02	0.02
2,000	0.37	0.28	0.22	0.18	0.14	0.12	0.10	0.08
3,000	0.78	0.61	0.49	0.39	0.32	0.26	0.22	0.18
4,000	1.30	1.04	0.83	0.68	0.56	0.46	0.38	0.32
5,000	1.88	1.53	1.24	1.02	0.85	0.70	0.59	0.50
6,000	2.49	2.06	1.70	1.40	1.18	0.98	0.83	0.70
7,000	3.12	2.62	2.19	1.82	1.54	1.29	1.10	0.93
8,000	3.76	3.19	2.69	2.26	1.93	1.63	1.39	1.19
9,000	4.39	3.76	3.21	2.72	2.34	1.99	1.71	1.48
10,000	5.01	4.33	3.73	3.18	2.76	2.37	2.05	1.77

TABLE 5

PUMP RATING DATA
Alligator Bayou Pump Station
(Assumes Avg. T.W. Elev. in Taylor's Bayou = +2.7')

Pond Elev.	Pool-to Pool Head	1 PUMP			2 PUMPS			3 PUMPS		
		Channel Head Loss	Total-Pump Head	Pump Capacity	Channel Head Loss	Total Pump Head	Pump Capacity	Channel Head Loss	Total-Pump Head	Pump Capacity
-2	4.7	0.15	4.85	1175	0.51	5.21	2330	1.04	5.74	3450
-1	3.7	0.11	3.81	1200	0.36	4.06	2380	0.86	4.56	3540
0	2.7	0.10	2.80	1220	0.30	3.00	2430	0.71	3.41	3630
+1	1.7	0.08	1.78	1235	0.27	1.97	2460	0.59	2.29	3675
+2	0.7	0.06	0.76	1245	0.18	0.88	2490	0.50	1.20	3720
+3	-0.3	0.04	-0.26	1250	0.15	-0.15	2500	0.46	0.16	3750
+4	-1.3	0.04	-1.26	1250	0.13	-1.17	2500	0.34	-0.96	3750
+5	-2.3	0.03	-2.27	1250	0.10	-2.20	2500	0.32	-1.98	3750

TABLE 5 - (Continued)

PUMP RATING DATA
Alligator Bayou Pump Station
(Assumes Avg. T.W. Elev. in Taylor's Bayou = +2.7')

Pond Elev.	Pool-to Pool Head	4 PUMP			5 PUMPS			6 PUMPS		
		Channel Head Loss	Total-Pump Head	Pump Capacity	Channel Head Loss	Total Pump Head	Pump Capacity	Channel Head Loss	Total-Pump Head	Pump Capacity
-2	4.7	1.57	6.27	4540	2.29	6.99	5575	2.92	7.62	6570
-1	3.7	1.39	5.09	4680	1.98	5.68	5750	2.56	6.26	6810
0	2.7	1.17	3.87	4780	1.69	4.39	5925	2.25	4.95	7020
+1	1.7	0.99	2.69	4880	1.44	3.14	6075	1.95	3.65	7230
+2	0.7	0.84	1.54	4940	1.24	1.94	6150	1.69	2.39	7350
+3	-0.3	0.70	.040	4980	1.05	0.75	6225	1.45	1.15	7440
+4	-1.3	0.59	-0.71	5000	0.90	-0.40	6250	1.24	-0.06	7500
+5	-2.3	0.50	-1.80	5000	0.76	-1.54	6250	1.06	-1.24	7500

TABLE 5 - (Continued)

PUMP RATING DATA
Alligator Bayou Pump Station
(Assumes Avg. T.W. Elev. in Taylor's Bayou = +2.7')

Pond Elev.	Pool-to Pool Head	7 PUMP			8 PUMPS		
		Channel Head Loss	Total-Pump Head	Pump Capacity	Channel Head Loss	Total Pump Head	Pump Capacity
-2	4.7	3.55	8.25	7490	4.11	8.81	8,400
-1	3.7	3.16	6.86	7840	3.74	7.44	8,800
0	2.7	2.79	5.49	8120	3.36	6.06	9,120
+1	1.7	2.46	4.16	8330	2.96	4.66	9,400
+2	0.7	2.17	2.87	8540	2.66	3.36	9,680
+3	-0.3	1.87	1.57	8645	2.32	2.02	9,400
+4	-1.3	1.63	0.33	8750	2.05	0.75	9,960
+5	-2.3	1.41	-0.89	8750	1.77	-0.53	10,000

TABLE 6
BEGINNING TAILWATER ELEVATIONS
FOR MAINS "A", "B" AND "C"

STARTING ELEVATION @ Alligator Bayou Pump Station	MAIN	EXISTING CONDITIONS	PROPOSED ALTERNATIVE 1	MAIN	PROPOSED ALTERNATIVE 2
-2	"A"	+1.5	+0.1	LOWER*	+1.9
-1		+1.9	+1.0	"A"	+2.2
0		+2.4	+1.6		+2.8
+1		+2.9	+2.1		+3.6
				UPPER**	
				"A"	+1.6
-2	"B"	+1.5	+0.1	"B"*	+1.9
-1		+1.9	+1.0		+2.2
0		+2.4	+1.6		+2.8
+1		+2.9	+2.1		+3.6
-2	"C"	+1.8	+0.6	LOWER*	+2.2
-1		+2.1	+1.3	"C"	+2.4
0		+2.6	+1.9		+3.0
+1		+3.1	+2.3		+3.7
				UPPER**	
				"C"	+1.0

* Locations of Beginning Tailwater Elevations for Lower "A", "B" and Lower "C" in Proposed Alternative 2 are same as the locations for Existing Conditions and Proposed Alternative 1.

** Locations of Beginning Tailwater Elevations for Upper "A" and Upper "C", in Proposed Alternative 2, are described in the report text.

TABLE 7
HEC-1 INPUT VARIABLES
(Proposed Alternative 2)

Drainage Area	Name	Area (Ac)	Dev. (%)	Base Flow(cfs)	Initial Loss(in.)	Infiltration (in/hr)	L (ft)	L_{ca} (ft)	C_t	TP (hr)
5A	UPPERC	1455	100	3.32	1.00	0.10	19,800	9400	2.20	3.89
5B	AIRPORT	1104	90	0	1.10	0.095	14,600	8800	2.44	3.86
26	MONT	351	90	0	1.10	0.095	7,200	3700	2.44	2.41
8	PS3	455	75	0	1.25	0.0875	6,200	1100	2.80	1.84
5C	MIDC	2653	90	8.14	1.10	0.095	16,300	6000	2.44	2.67
5D	LOWC	2809	0	9.94	2.00	0.05	19,000	6900	4.60	7.33
6A	UPPERB	2951	100	0	1.00	0.10	19,800	8100	2.20	3.72
6B	LOWB	1252	100	6.01	1.00	0.10	15,200	6700	2.20	3.25
9A	UPPERA	1673	100	4.02	1.00	0.10	19,800	8400	2.20	3.76
9B	A-3	1250	75	6.44	1.25	0.0875	13,900	5800	2.44	3.36
9D	MIDA	483	25	1.73	1.75	0.0625	10,000	5000	4.00	4.77
9C	LOWA	538	100	1.95	1.00	0.10	14,600	6300	2.20	3.15
12	PEAR	3654	90	0	1.10	0.0875	19,100	6600	2.44	3.84
27D	SPOIL	455	0	2.18	2.00	0.050	8,400	3000	4.60	4.47
25	VISTA	122	100	0	1.00	0.10	5,200	2700	2.20	1.79
24	PS2	1013	100	0	1.00	0.0.10	9,700	3700	2.20	2.37
27B	TEXCHE	129	75	0	1.25	0.0875	4,000	1000	2.80	1.59
27C	TEXRES	51	50	0	1.50	0.075	3,300	2000	3.40	2.21
14	CENT	1903	100	0	1.00	0.10	13,500	4900	2.20	2.85
27A	IND	1111	0	42.27	2.00	0.05	13,200	3900	4.60	5.53
		25,412		86.00						

TABLE 8
AREA OF PONDING
(Acres)

MAIN	EXISTING CONDITIONS PONDING	PROPOSED ALTERNATIVE 1 AREA OF PONDING	PROPOSED ALTERNATIVE 1 AREA RECLAIMED	PROPOSED ALTERNATIVE 2 AREA OF PONDING (Includes Detention Ponds)	PROPOSED ALTERNATIVE 2 AREA RECLAIMED (Not Including Detention Ponds)
"A" & "B"	2650	2140	510	110	2540
"C"	4255	3295	960	3510	745
MAIN OUTFALL CHANNEL	455	455	0	455	0
TOTAL	7360	5890	1470	4075	3285
LATERAL "A-3"	1200	0	1200 *	0	1200 *

*Assumes upgrading of inadequate crossings described in text.

SECTION VIII

REFERENCES

1. U.S. Army Engineer District, Galveston, Corps of Engineers, Port Arthur and Vicinity, Texas, Hurricane Flood Protection, Design Memorandum No. 1B, Hydrology (Interior Drainage). Galveston, Texas, April 1965.

2. Jefferson County Drainage District No. 7, Alligator Bayou Watershed Study, by Turner, Collie and Braden, Inc., Port Arthur, Texas, August 1981.

3. U.S. Army Engineer District, Galveston, Corps of Engineers, Port Arthur and Vicinity, Texas, Hurricane Flood Protection, Operation of Alligator Bayou Pumping Station, Galveston, Texas, May 1984.

4. U.S. Army Engineer District, Galveston, Corps of Engineers, Port Arthur and Vicinity, Texas, Hurricane Flood Protection, Operation and Maintenance Manual for Alligator Bayou Pumping Station and Gravity Drainage Structure, Galveston, Texas, Undated.

5. Williams-Stackhouse, Inc. of San Antonio, Texas, Aerial Contour Maps for City of Port Arthur and Jefferson County Drainage District No. 7, Texas, Scale 1" = 200', 1 foot Contour Interval, compiled March, 1976.

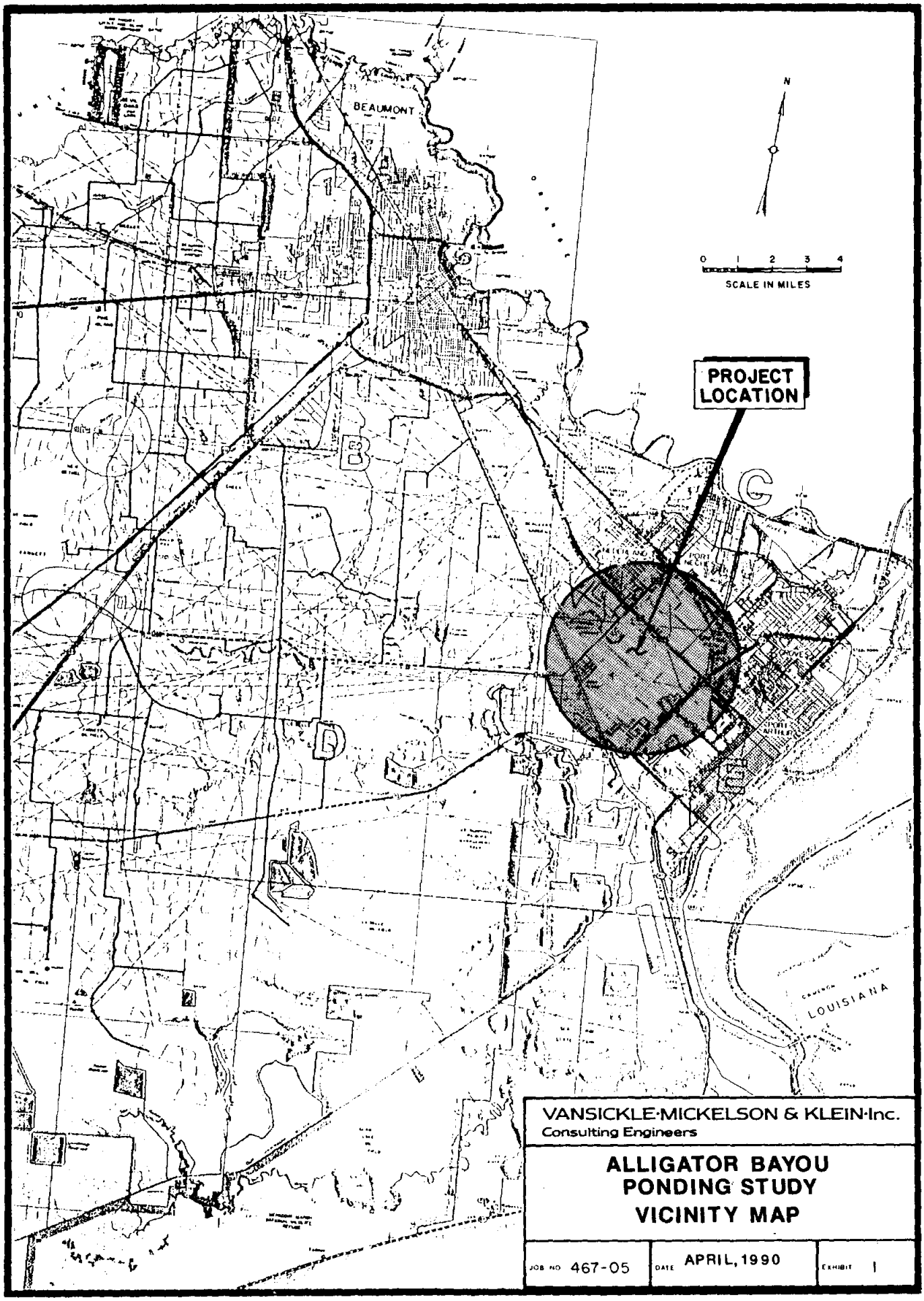
6. U.S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-1 Flood Hydrograph Package, Users Manual, Davis, California, September 1981, Revised March, 1987.

7. U.S. Army Corps of Engineers, Hydrologic Engineering Center, Interior Drainage Flood Routing, Users Manual, Davis, California, March 1969, Updated November 1978.

8. U.S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-2 Water Surface Profiles, Users Manual, Davis, California, September 1982.

SECTION IX

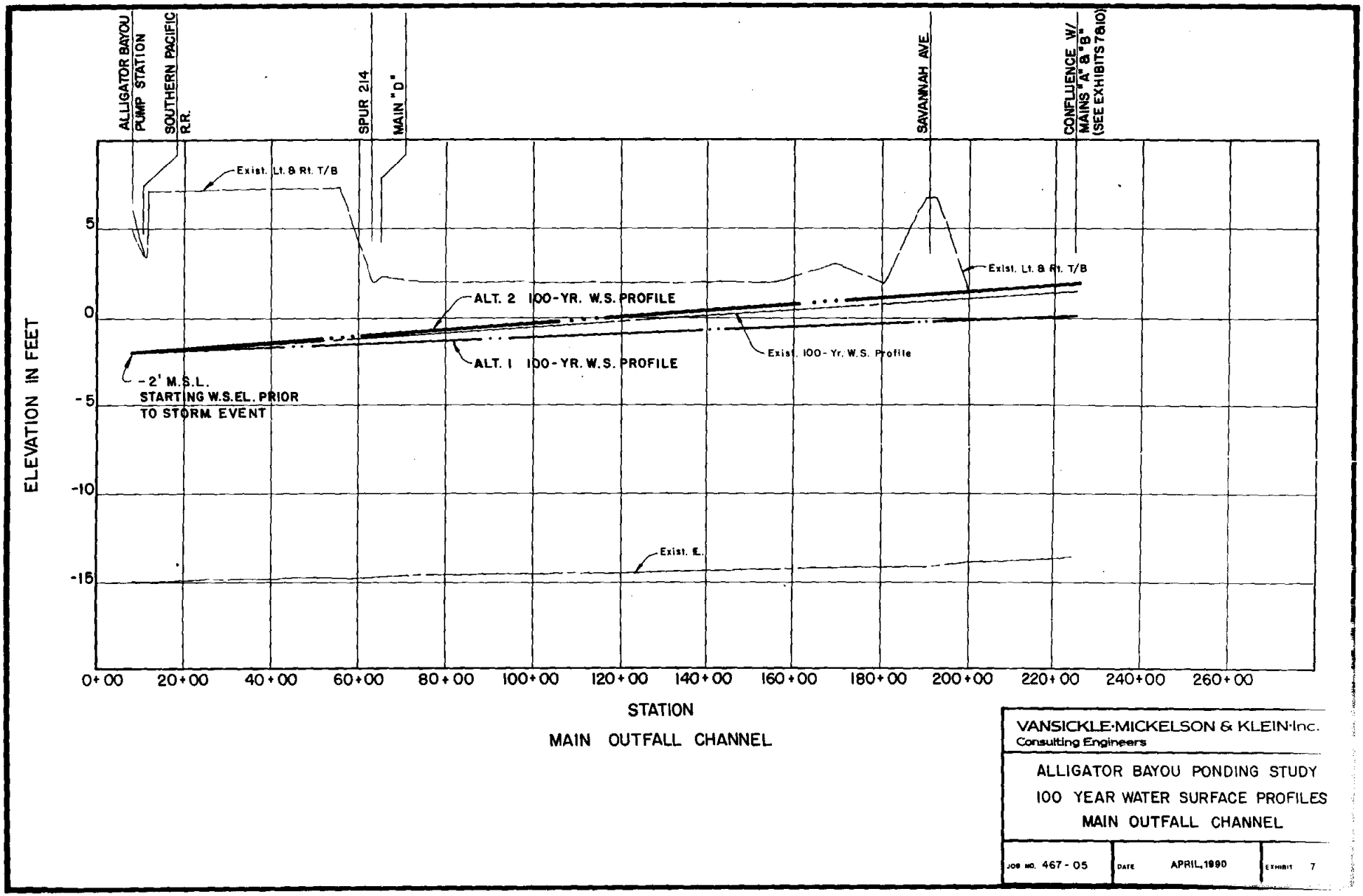
EXHIBITS



VANSICKLE·MICKELSON & KLEIN·Inc.
Consulting Engineers

ALLIGATOR BAYOU PONDING STUDY VICINITY MAP

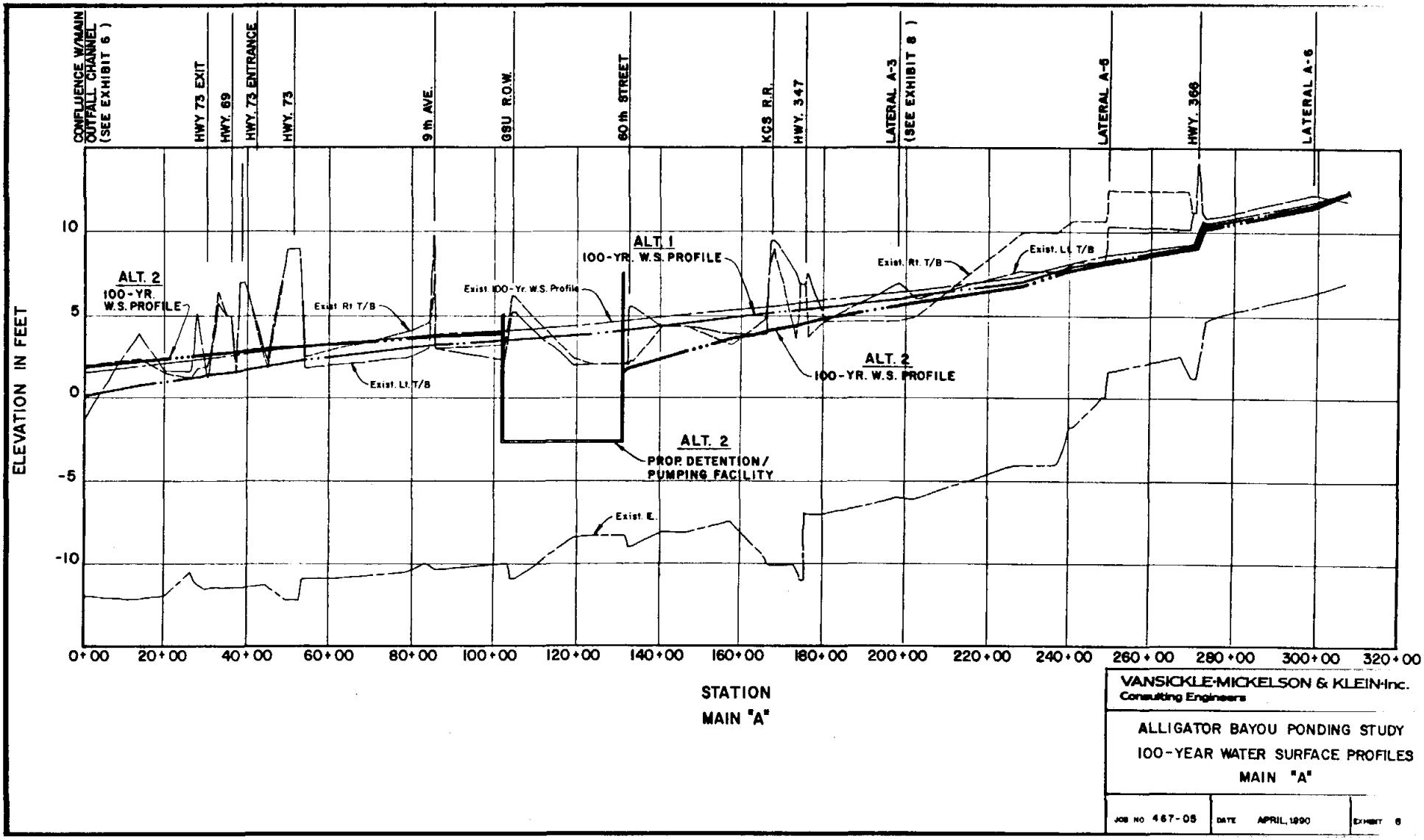
JOB NO 467-05	DATE APRIL, 1990	EXHIBIT 1



VANSICKLE·MICKELSON & KLEIN·Inc.
Consulting Engineers

ALLIGATOR BAYOU PONDING STUDY
100 YEAR WATER SURFACE PROFILES
MAIN OUTFALL CHANNEL

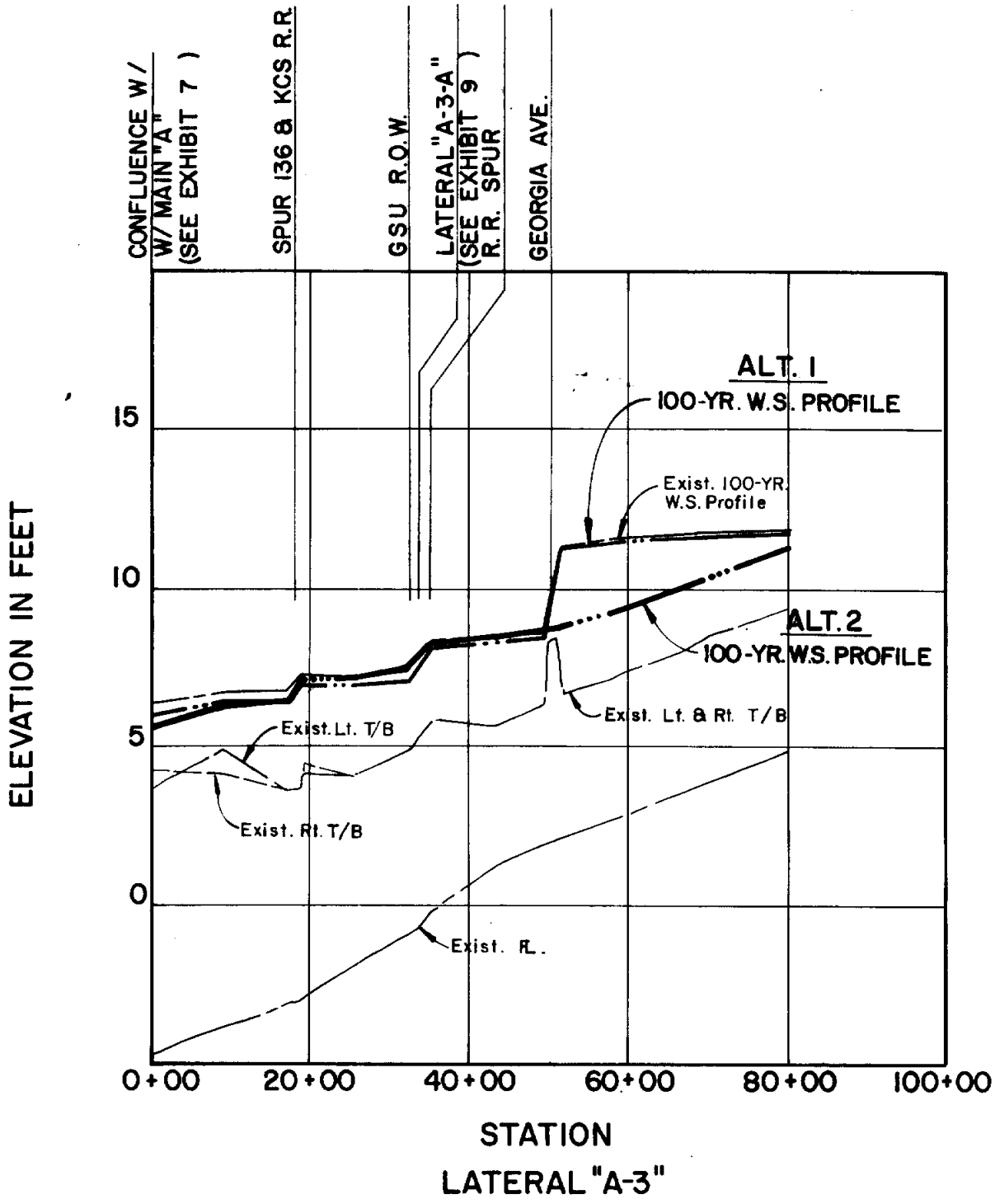
JOB NO. 467 - 05	DATE APRIL, 1990	EXHIBIT 7



VANSICKLE-MICKELSON & KLEIN-Inc.
Consulting Engineers

ALLIGATOR BAYOU PONDING STUDY
100-YEAR WATER SURFACE PROFILES
MAIN "A"

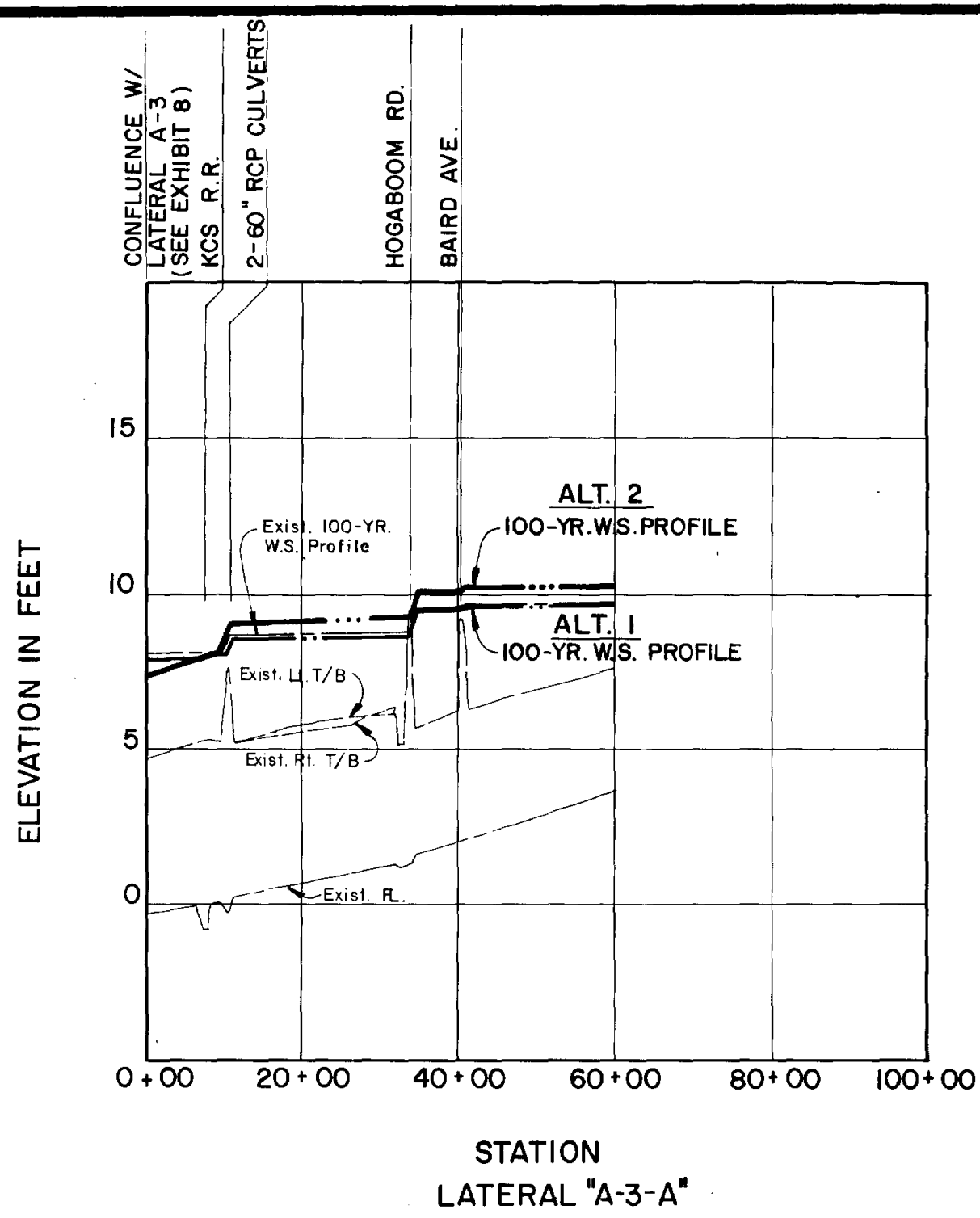
JOB NO 467-05 | DATE APRIL, 1990 | EXHIBIT 6



VANSICKLE-MICKELSON & KLEIN-Inc.
Consulting Engineers

ALLIGATOR BAYOU PONDING STUDY
100 YEAR WATER SURFACE PROFILES
LATERAL "A-3"

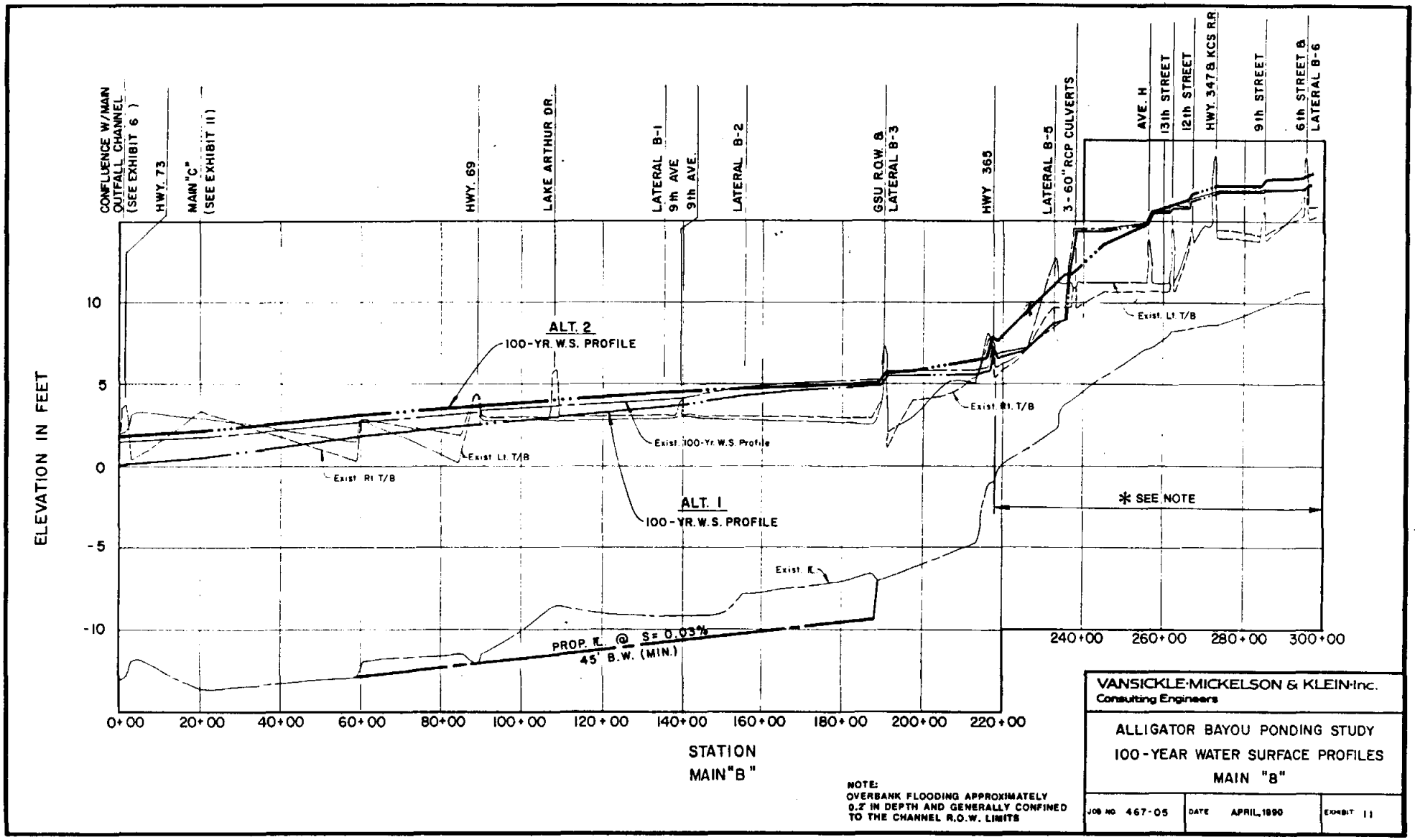
JOB NO 467-05	DATE APRIL, 1990	EXHIBIT 9



VANSICKLE·MICKELSON & KLEIN·Inc.
Consulting Engineers

ALLIGATOR BAYOU PONDING STUDY
100-YEAR WATER SURFACE PROFILES
LATERAL "A-3-A"

JOB NO 467-05	DATE APRIL, 1990	EXHIBIT 10

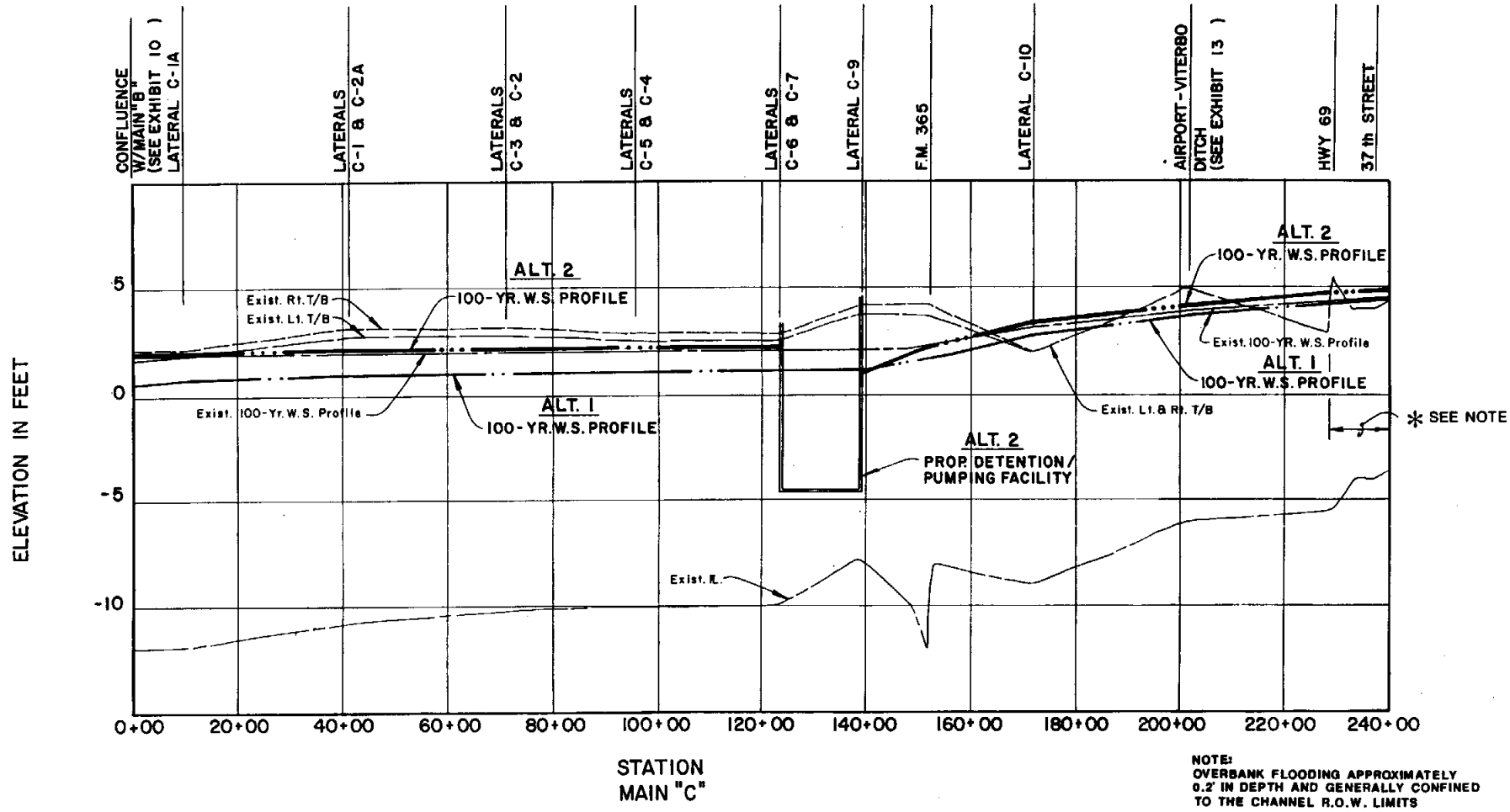


NOTE:
OVERBANK FLOODING APPROXIMATELY 0.3' IN DEPTH AND GENERALLY CONFINED TO THE CHANNEL R.O.W. LIMITS

VANSICKLE·MICKELSON & KLEIN·Inc.
Consulting Engineers

ALLIGATOR BAYOU PONDING STUDY
100-YEAR WATER SURFACE PROFILES
MAIN "B"

JOB NO. 467-05	DATE APRIL, 1990	EXHIBIT 11



NOTE:
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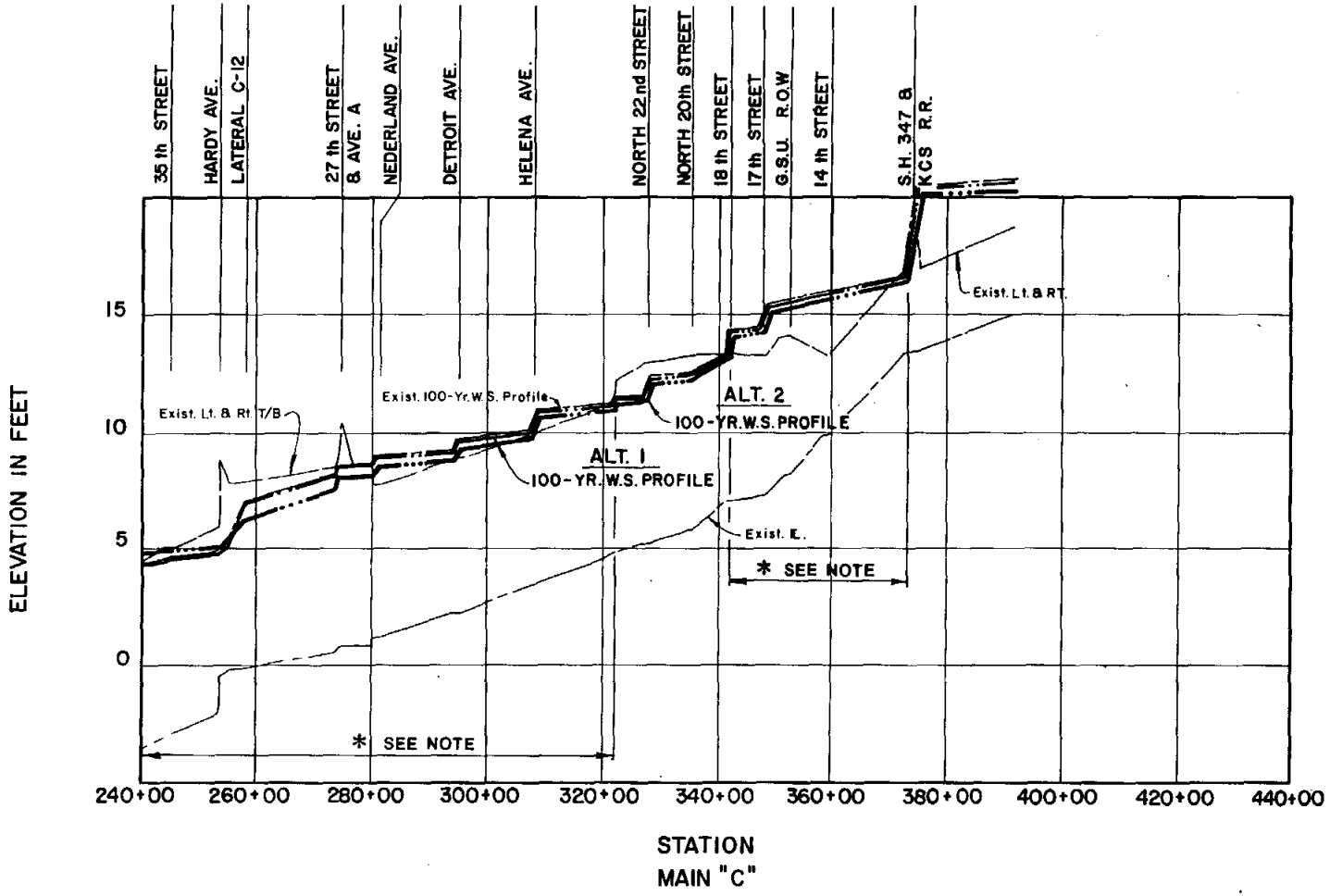
VANSICKLE·MICKELSON & KLEIN·Inc.
Consulting Engineers

ALLIGATOR BAYOU PONDING STUDY

100-YEAR WATER SURFACE PROFILES
MAIN "C"
STA. 0+00 TO STA. 240+00

JOB NO. 467-05	DATE APRIL, 1990	EXHIBIT 12

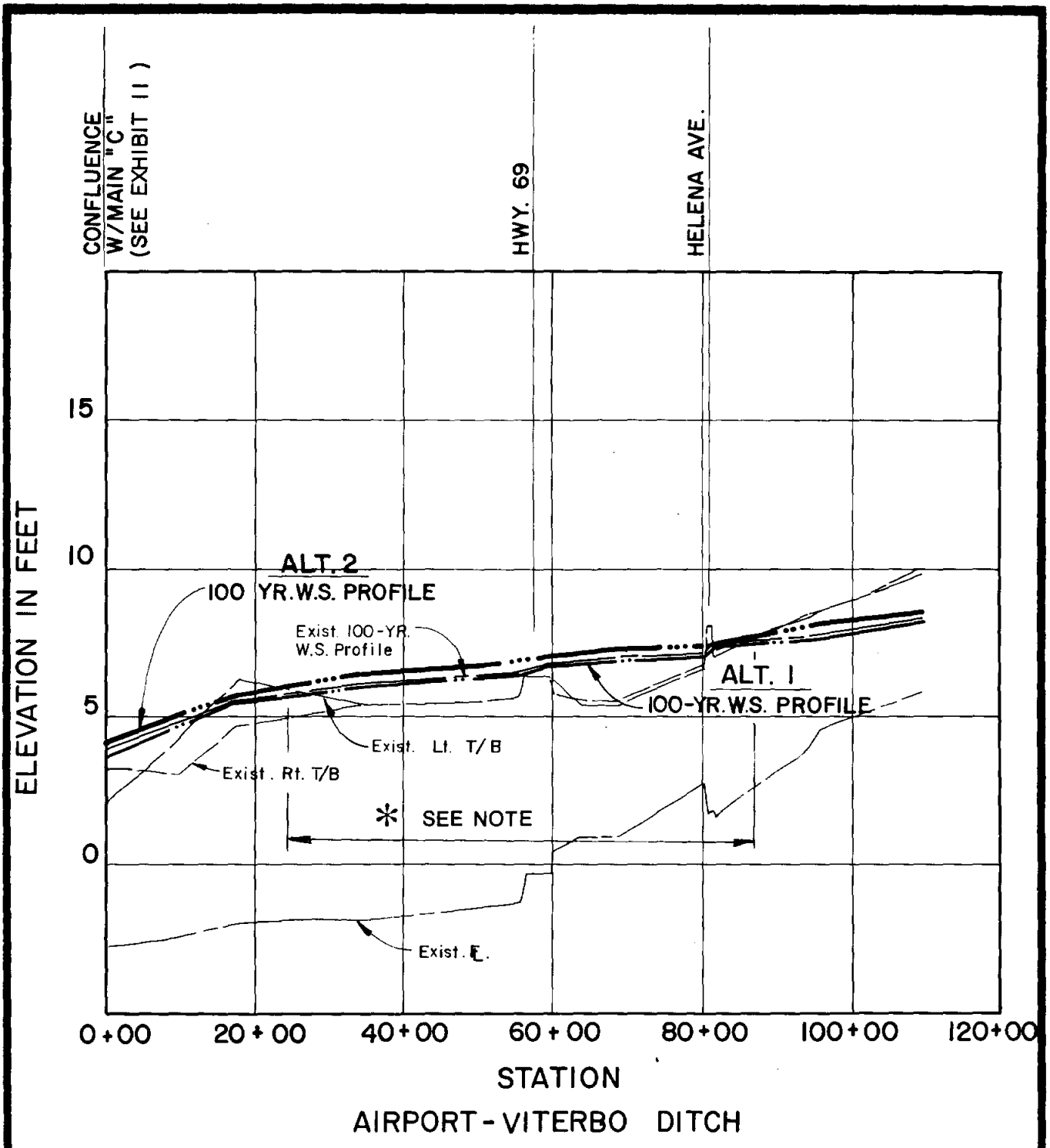


NOTE:
OVERBANK FLOODING APPROXIMATELY 0.2' IN DEPTH AND GENERALLY CONFINED TO THE CHANNEL R.O.W. LIMITS

VANSICKLE-MICKELSON & KLEIN-Inc.
Consulting Engineers

ALLIGATOR BAYOU PONDING STUDY
100-YEAR WATER SURFACE PROFILES
MAIN "C"
STA. 240+00 TO STA. 394+00

JOB NO 467-05	DATE APRIL, 1990	EXHIBIT 13



AIRPORT - VITERBO DITCH

NOTE:
OVERBANK FLOODING APPROXIMATELY 0.2' IN DEPTH AND GENERALLY CONFINED TO THE CHANNEL R.O.W. LIMITS

VANSICKLE·MICKELSON & KLEIN·Inc.
Consulting Engineers

ALLIGATOR BAYOU PONDING STUDY
100-YEAR WATER SURFACE PROFILES
AIRPORT - VITERBO DITCH

JOB NO 467-05	DATE APRIL, 1990	EXHIBIT 14

SECTION X

APPENDICES

Alligator Bayou Ponding Study
Port Arthur, Texas

Appendix A

Environmental Setting, Impacts of Alternatives, and Mitigation Potential

Karen M. Wicker, PhD

Coastal Environments, Inc.
1260 Main Street
Baton Rouge, LA 70802

Location and Physical Setting

Location

The study area is located in the Strandplain Region of Southeast Texas immediately west of Sabine Lake. The site is defined by the 100-year ponding limits and consists of open and semi-developed land served by three major drainage canals, Main "A", Main "B", and Main "C". The area can be divided into two major components: 1) Area A located between the Southern Pacific Railroad and US Hwy 69, and Area B east of US Hwy 69 and north of State Hwy 73 (Figure A-1). The City of Port Arthur is located southeast of Main "C", while the communities of Pear Ridge, Griffic Park and Groves are east of the area served by Mains "B" and "A". Port Neches and Nederland are located north of these latter Mains and Port Acres is to the west of Main "C". The Jefferson County Airport is west of and adjacent to the Main "C" area.

Geology, Wetlands, and Soils

Prior to being isolated by drainage systems, flood protection levees, roads, and development, the southern portion of the present 100-year ponding limits was part of the continuous, Modern Marsh System that extended to the Gulf of Mexico (White et al. 1987, Fisher et al. 1973) (Figure A-2). These extensive, coastal marshes in this Marsh System are diminishing in area because of canal dredging, reduction in sediment supply, sea level rise, saltwater intrusion into fresh marsh habitat, natural and man-induced subsidence, impoundment, and filling for development (White et al. 1987). Within the entire Sabine River Basin of Texas and Louisiana, Gosselink et al. (1979) calculated a marsh loss of approximately 50,700 acres between 1952 and 1974. A recent study of the wetlands in the lower Neches River Valley, immediately north of the study area, revealed that 9,410 acres of fresh-to-brackish marsh were lost between 1956 and 1978 (White et al. 1987). The lower-lying wetlands remaining in the southern area of the study site are freshwater marshes isolated from tidal influence. They are impacted by man-induced processes, such as burning, grazing, ditching, spoiling, and impounding, and have no management to enhance their natural productivity.

Two soils cover most of the area within the existing 100-year ponding limits: Harris clay and Beaumont clay (Exhibit A-1). A third soil, Morey silt loam, fringes the northern and western perimeter of the area and there are several small pockets of Bibb clay loam, Made land and Oil Waste land throughout the area. The Harris clay occurs in an area that was part of the Holocene-Modern Marsh System. The Beaumont clay and Morey silt loams are within the Pleistocene Delta System (Figure A-2). The characteristics and uses of these soils are summarized in Table A-1. Basically, the Harris and Beaumont clays are located on nearly level or level to depressed sites and are poorly to very poorly drained. Harris clays have a permanently high water table and require major reclamation efforts to make them suitable for uses other than as wildlife habitat or unimproved pasture lands (US Dept. of Agri. 1965).

Vegetation and Land Use

Vegetation and land use are significantly different between Areas A and B. Area A is a bowl-shaped depression with the rim defined by man-made levees or spoil banks, and highways built on embankments. The elevations around the rim range from 1 to 2 feet while the center of the area is -1 foot or less in elevation. A major petroleum field once operated in the center of Area A and may account for the formation of this depression.

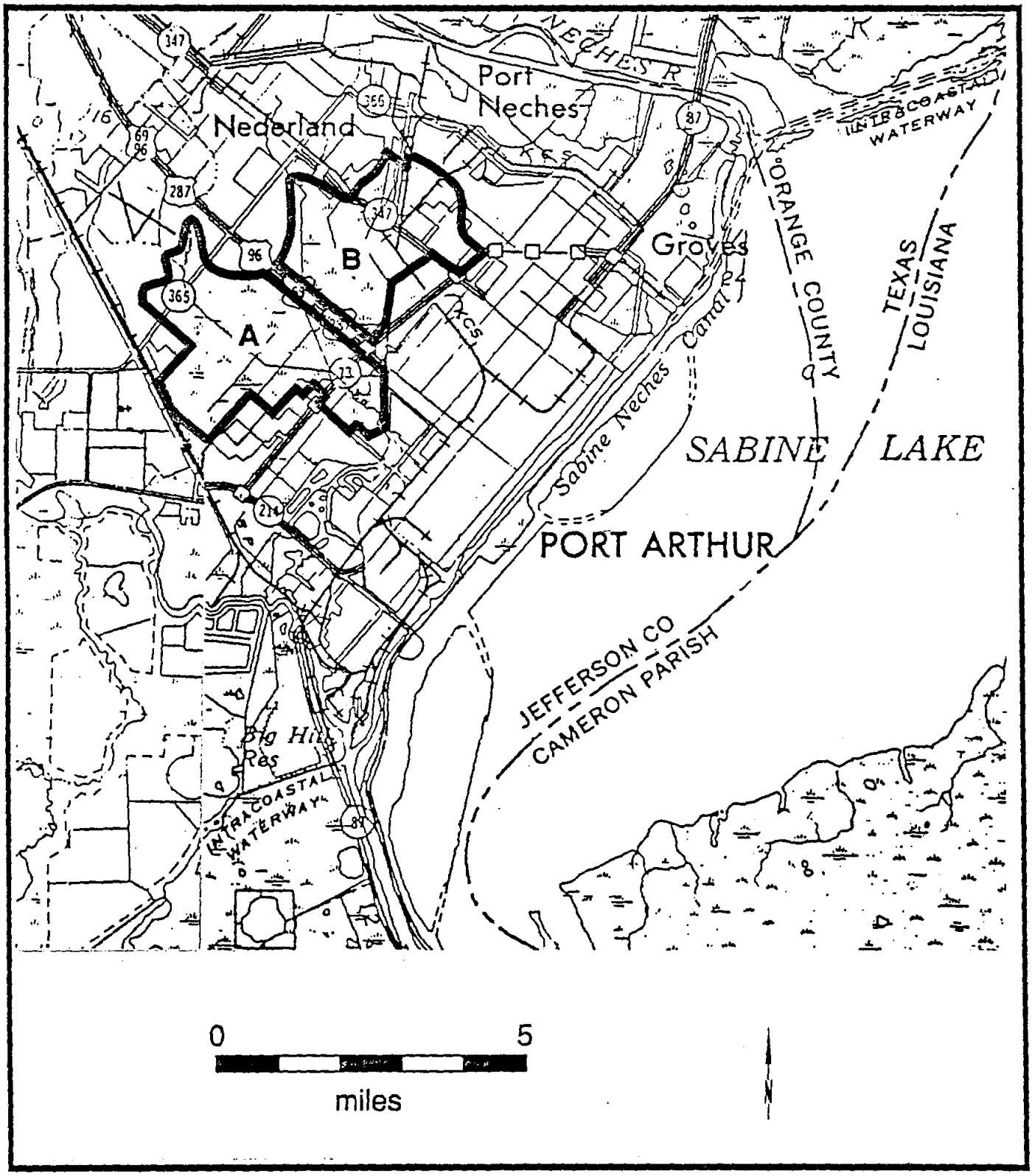


Figure A-1. Approximate Location of Areas A and B in 100-year Ponding Limits. (Note: Major highways in each area are outside of the ponding limits.)

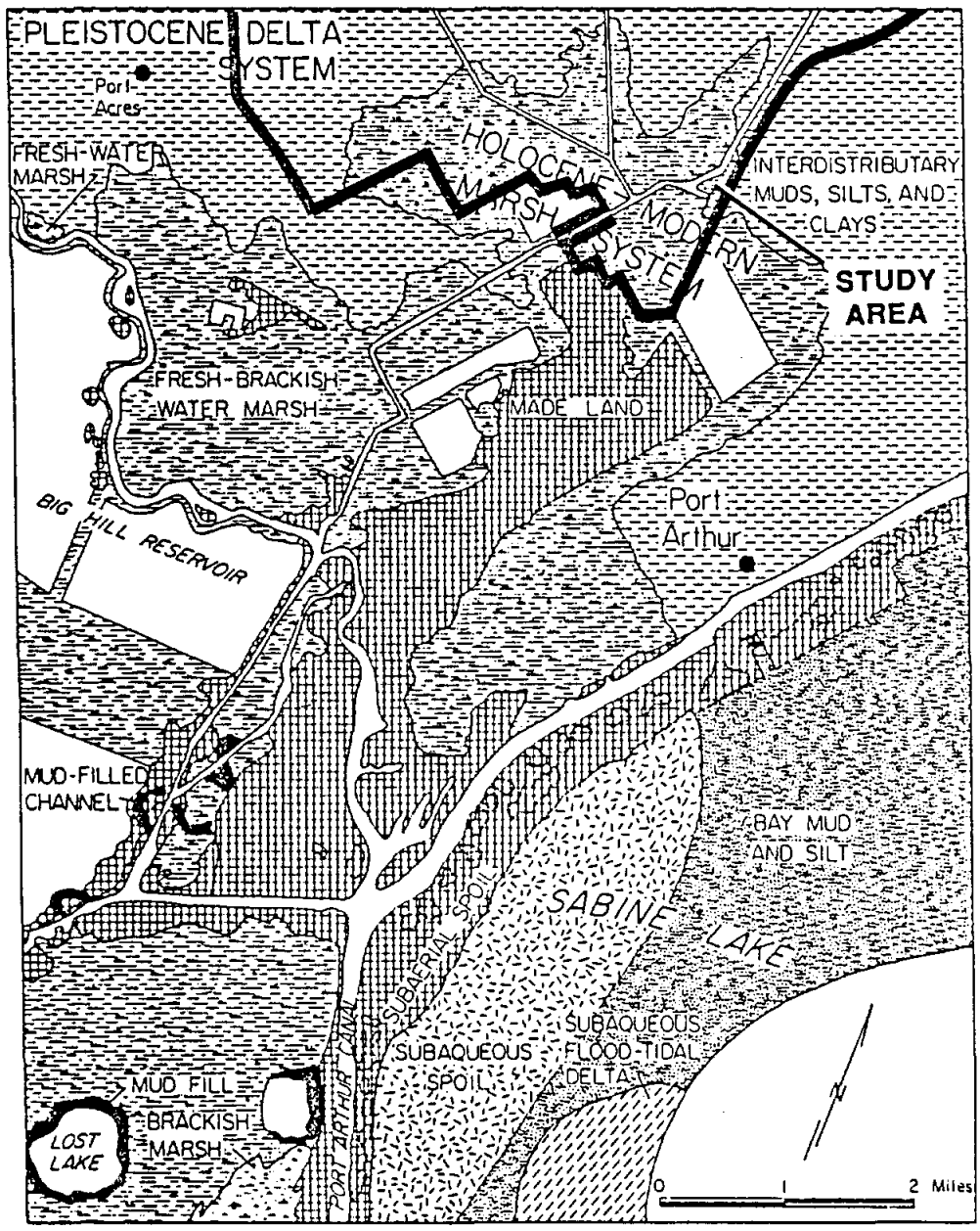


Figure A-2. Geologic setting of a portion of the study area (Fisher et al. 1973).

Table A-1. Characteristics of Hydric Soils Within Study Area (USDA 1965).

Soil Name	Capability Unit	Description	Use and Management	Woodland Suitability	Wildlife Suitability
Harris clay	VII w-1	Level to depressed, very poorly drained, saline soils of the coast marsh. Developed under coarse, salt-tolerant grasses and sedges	Saltmarsh range site: deep saline clay, unstable subsoil, and normally affected daily by saltwater tides; permanantly high water table; suitable for wildlife; major reclamation needed before area suitable for other uses	Not stated	Well suited for furbearers, ducks, and geese.
Beaumont Clay	III w-1	Level to nearly level; poorly drained soils that have a very tight subsoil. Upper layer sticky and plastic when wet, very hard when dry	Blackland Range Site: deep, moderately productive; strongly acid to mildly alkaline clays; Potential vegetation: tall grass prairie type, native range, improved pasture and feed sorghum	Group 7: Not normally suited for trees but can be planted (slash pine, loblolly pine, white oak, red oak, sweetgum	Group 1: Soils especially suitable for planting duck food or for flushing with irrigation waters to make existing seed available (as in rice fields). Spoil areas provide protection for quail, rabbits, upland wildlife, and furbearers
Morey Silt Loam	III w-1	Level to nearly level, poorly drained soils that have a very tight subsoil. Upper layer sticky and plastic when wet, very hard when dry	Loamy Prairie Range Site: nearly level to depressed areas that are affected only by fresh water, deep, acid, poorly to very poorly drained loamy soils	Group 7: Not normally suited for trees. Where soil is strongly to medium acid, supports good growth of mixed pine and hardwoods	Group 1: soils especially suitable for planting duck food or for flushing with irrigation waters to make existing seed available (as in rice fields. Spoil areas provide protection for quail, rabbits, upland wildlife, and furbearers

Mains "C" and "B" converge in the eastern part of Area A and drain the site into the Main Outfall Canal which is discharged into Taylors Bayou at the Alligator Pump Station. However, the depressed shape, poorly drained soils, and location at the confluence of unleveed drainage canals have resulted in most of Area A remaining as a well defined wetland with saturated-to-flooded soils.

In the recent past, the western and northern perimeter of Area A was in rice cultivation. Now the primary agricultural use is for pasture. Discontinuous spoil deposits along the main and lateral drainage canals and embankments and the better drained Beaumont clays of former rice fields are functioning as transitional areas being invaded by a scrub/shrub community dominated by Chinese tallow (Sapium sebiferum), but mixed with willow (Salix spp.), yaupon (Ilex sp.), wax myrtle (Myrica sp.), Eastern baccharis (Baccharis halimifolia), and rattlebush (Sesbania drummondii) (Exhibit A-2). The interior and southern portions of this area have an emergent vegetation with remnants of tidal marsh vegetation mixed with freshwater plants. The distribution of vegetation assemblages will vary through time depending upon factors such as season of the year, current flooding regime or hydroperiod, animal grazing, mowing, and burning. However, a brief field reconnaissance to a portion of the site on November 17, 1988 confirmed the general vegetation distribution recorded by Irby in 1982. His extensive field survey noted the following vegetation within the wetter portions of Area A: cordgrasses (Spartina spp.) cattails (Typha spp.), paspalums (Paspalum spp.) softstem bulrushes (Scirpus spp.), common rushes (Juncus spp.), cutgrass (Zizaniopsis miliacea), dwarf spikerush (Eleocharis parvula), fall panicum (Panicum dichotomiflorum) and millets (Echinochloa spp.). On the drier sites, Irby (1982) mapped Chinese tallow, willow, Eastern baccharis, asters (Aster spp.), beaked rush (Rhynchospora spp.), rattlebush, ragweeds (Ambrosia spp.), and smartweeds (Polygonum spp.).

At present, Area A functions as a ponding area for precipitation and run-off, a grazing site and habitat for a variety of wildlife including small mammals (such as nutria, muskrats, river otters, gray foxes, and coyotes), wading birds and shorebirds, migratory birds and waterfowl, resident ducks, fish, reptiles, amphibians and insects. Portions of the area have been leased for duck hunting in recent years. One large borrow pit, in the center of the area west of US Hwy 69 is being mined for fill material and several small commercial/industrial establishments have been constructed adjacent to perimeter highways (State Hwy 365 and US Hwys 96, 69, 287). In the center of Area A east of Main "C", there is an elevated, former petroleum "processing" facility site that is now owned by Drainage District No. 7 and slated for use as a dredge material disposal site. Area A is segmented also by numerous lateral drainage canals, low spoil banks, and abandoned well access roads. The lateral ditches intersect perpendicularly to Main "C" and function as habitat for aquatic wildlife, diving birds and ducks, and water dependent mammals. Numerous pipelines cross the property, generally in a northeast-southwest direction,and abandoned well sites and pits dot the area.

The southernmost segment of Area A is located between the Texaco Reservoir and the Main Outfall Canal. Interpretation of recent color infrared photography (NASA 1985) indicated that this is an impounded wetland with standing water on the south side and shrubs growing on dredge material disposal sites on the northern perimeter and along the impounding levees. This part of Area A is segmented into five subunits by canals and levees. Prior to impoundment, a tidal channel connected to Taylors Bayou traversed this area in a north-south direction. This site will remain within the 100-year ponding limits under implementation of Alternative 1 or 2.

Area B, located east of State Hwy 69, has higher elevations ranging from 1 foot on the south side to 10 feet on the northeast. Most of this site is fairly well drained with only the southern wedge, located on Harris clay soils between US Hwy 69 and Main "A", having standing water (NASA 1985). Most of the remainder of Area B consists of Beaumont clays with undeveloped areas having transitional stages consisting of pasture, mowed grassland and scrub/shrub

communities. The site is segmented by numerous roads and ditches and there are residential, commercial, and industrial developments constructed along roads throughout the area. This site also has several reservoirs or flooded impoundments, some of which are for industrial uses, and a large golf course along its western perimeter. With regard to the presence of threatened and endangered species and archaeological resources please see Exhibits A-3 and A-4.

Impacts of Alternatives To Improve Alligator Bayou Drainage System

Alternative 1: Pumping Option

At present, approximately 2,650 acres of Area B and 4,255 acres of Area A are subject to flooding because they are within the 100-year ponding limits. Implementation of Alternative 1 will remove 1,470 acres of land from the 100-year ponding limits: 510 acres of Area B and 960 acres of Area A.

In Area B, the potential reclaimed land lies along the northern perimeter of the unit on Beaumont clays. Present land use includes a golf course, commercial establishments, residential areas with houses and/or transportation and utility infrastructures, and mowed urban lots with scattered shrubs and small trees.

In Area A, the potentially reclaimable land consists of Beaumont clay lying above the 1 foot contour along the western perimeter of the unit. The reclaimed area west of Main "C", near the Southern Pacific Railroad tracks, was recently used for rice production and presently represents a transitional zone being invaded by Chinese tallow, baccharis and rattlebush. A similar condition exists for the reclaimed area northwest of State Hwy 365 and south of lateral "C-10" (south of the airport). The reclaimable land southeast of State Hwy 365 is already largely developed with commercial and light industrial enterprises, or in mowed pasture land with scattered areas of shrubs and small trees.

The site which will be reclaimable north of lateral "C-10" and along the northern perimeter of Area A is largely abandoned rice fields being invaded by shrubs and trees such as Chinese tallow, willow, and Eastern baccharis. The lower-lying, poorly drained areas still contain emergent vegetation such as cordgrass, smartweeds, cattails, and rushes. A few scattered commercial developments are located in this area adjacent to US Hwy 69.

The 960 acres reclaimable with Alternative 1 can be expected to accelerate their transition from a wetland to an upland community as upland plants, intolerant of flooding, invade the site. The 3,295 acres which remain within the 100-year ponding limits will continue to support flood tolerant vegetation with distribution of plant communities being primarily responsive to variations in flood regimes (i.e., drought versus wet or normal years), grazing and burning practices. Implementation of wetland management practices would improve the habitat value of the site for wildlife, especially ducks and geese. No development requiring deposition of fill material or permanent lowering of the water table can be expected within the unreclaimed area (3,295 acres) because the site is a wetland due to the presence of hydric soil, hydrophytic vegetation and wetland hydrology.

Alternative 2: Detention-Pumping Option

Implementation of Alternative 2 will result in a total of 3,285 acres of reclaimed land: 2,540 acres in Area B and 745 acres in Area A. Alternative 2 will require a 275-acre detention pond in Area A and a 110-acre detention pond in Area B.

The 2,540 acres of Area B which are to be reclaimed presently consist of scattered residential, commercial and industrial sites, impoundments and reservoirs, roads, drainage canals and ditches, mowed city lots and larger pasture areas, shrub covered lots, a golf course and a relatively small unit of emergent grassland-wet pasture at the juncture of State Hwy 69 and Main "A". This latter site appears to function as a viable wetland more than other sections of Area B because of the presence of emergent grassland and small standing water areas. Under present Corps of Engineers' guidelines, much of the undeveloped portions of this unit may be considered wetland based on the presence of hydric soils, wetland hydrology (i.e, saturated soils during the growing season), and existing or potential (in the absence of mowing and/or planting of commercial grasses) hydrophytic vegetation. However, all sites have been modified by man, to some extent, and habitat value varies significantly with location.

Interpretation of a 1985 (NASA) aerial photograph indicates that construction of a 110-acre pond along Main "A" at the juncture of 60th Street and the Kansas City-Southern Railroad tracks, will destroy some structures, transitional shrub-covered areas, mowed and/or grazed grasslands, and a small area of fresh marsh at the southern end of the proposed pond.

Implementation of Alternative 2 in Area A will require construction of flood protection levees along drainage lateral "C-7" from the Montrose Pump Station on the west to the juncture of "C-6" and "C-6-A". This levee would extend southeast of "C-6-A" parallel to US Hwy 69 to the latitude of "C-2" where it would bend north to connect with US Hwy 69. A 275-acre detention pond would be constructed on the northwest side of the levee and "C-6".

This plan will reclaim a smaller net area of land in Area "A" than will Alternative 1 because 275 acres will be in a detention pond. Furthermore, some of the area immediately northwest of "C-6" which would have been reclaimable under Alternative 1 will now be converted to a detention pond. However, Alternative 2 reclaims a larger segment of property along Main "C" between State Hwy 365 and the Jefferson County Airport. This additional, reclaimable land presently consists of spoil banks along drainage canals, poorly drained shrub and grassland habitat, and depressions with emergent grasses such as rushes and cattails. The 3,510 acres which remain unreclaimable under Alternative 2, can be expected to function as described in Alternative 1.

Wetlands Determination and Constraints on Land Use

On January 10, 1989, four Federal regulatory agencies (Fish and Wildlife Service, Environmental Protection Agency, Department of the Army, and Soil Conservation Service) adopted the Federal Manual for Identifying and Delineating Jurisdictional Wetlands (referred to as the Manual). The criteria established in this Manual are being used by the Environmental Protection Agency (EPA) and the Corps of Engineers (CE) in administering the Section 404 permit program which governs dredge and fill operations in wetlands. The Soil Conservation Service (SCS) is using the Manual to identify wetlands in agricultural areas belonging to farmers applying for US Department of Agriculture (USDA) program benefits under the "Swampbuster" provision of the Food Security Act of 1985. The Fish and Wildlife Service will adhere to these criteria in their classification and delineation of wetlands (Federal Interagency Committee for Wetland Delineation [FICWD] 1989).

While the CE makes the wetland determination which is subject to final review and approval by EPA, the criteria for identifying jurisdictional wetlands as presented in the Manual were consulted in preparing the map depicting vegetation zones and land use in the study area (Exhibit A-2). Vegetation zones, rather than individual communities were mapped because the interpretation was based on a brief reconnaissance (November 17, 1988) to a portion of the site to verify a previous study (Irby 1982) and to ground check a recent, small scale, color infrared photograph (NASA 1985). Also consulted for this interpretation was the map showing

"Distribution of Wetlands and Benthic Macroinvertebrates, Submerged Lands of Texas, Beaumont-Port Arthur Area" (White et al. 1987).

In order for an area to be declared a wetland, three mandatory criteria must be met: hydrophytic vegetation, hydric soils and wetland hydrology (FICWD 1989:5). Hydrophytic vegetation is defined as "macrophytic plant life growing in water, soil or on a substrate that is at least periodically deficient in oxygen as a result of excessive water content" (FICWD 1989:5). The hydrophytic vegetation criterion is met if:

1. more than 50 percent of the composition of the dominant species from all strata are obligate wetland (OBL), facultative wetland (FACW), and/or facultative (FAC) species or

2. a frequency analysis of all species within the community yields a prevalence index value of less than 3.0 (where OBL = 1.0, FACW = 2.0, FAC = 3.0, FACU = 4.0, and Upland = 5.0) (FICWD 1989: 5).

If the area has hydric soils and wetland hydrology, but the criteria described above are not quite met, the site is considered to be a problem area wetland, but a wetland never the less (FICWD 1989:5).

The areas mapped as emergent wetland on Exhibit A-2 are located primarily in Area A and contain species (i.e., cattails, bulrushes, cordgrasses, panicums, smartweeds, millets, spikerushes, and paspalums) that have indicator status as obligate wetland, facultative wetland or facultative species. The area depicted as urban grassland (Area B on Exhibit A-2) appears to be better drained with the vegetation being kept short either by mowing or grazing. Several of these urban grassland sites are located on golf courses or industrial sites. There are pockets of wetter areas, as seen on the 1985 aerial photograph, but these are too small and scattered to depict on this scale map. It would require field inspection to verify the wetland indicator status of plants on the urban grassland areas, therefore, these sites were delineated separately from emergent wetland.

Exhibit A-2 denotes scattered patches of scrub/shrub habitats. Within Area A, field investigations verified Irby's (1982) identification of these areas as being invaded primarily by overstory vegetation dominated by Chinese tallow, with willows, baccharis and rattlebush. These species have an indicator status of facultative, obligate, facultative, and facultative wet, respectively, thus indicating that these sites have hydrophytic vegetation.

Scrub/shrub habitat in Area B is likely to have the same overstory vegetation as is present in Area A. In many places, there appear to be wet soils showing between the overstory (NASA 1985). Dredged material disposal sites in Areas A and B will be elevated and better drained even though they may contain an overstory (i.e., Chinese tallow) similar to that of lower lying areas. Such sites, perhaps, may qualify as nonwetland because of their Made land classification and better drainage.

The second criterion for designating a wetland site is that the soils be hydric, i.e., "flooded, ponded, or saturated for usually one week or more during the period when soil temperatures are above biologic zero 41°F" (FICWD 1989:6). All three natural soils (Harris clay, Beaumont clay, and Morey silt loam) mapped for the site (USDA 1965) are classified as hydric soils (Environmental Laboratory 1987). While the Manual (FICWD 1989:6) notes that "caution must be exercised in using the hydric soils list for determining the presence of hydric soils at specific sites", soils testing would be required to prove that a specific site within the study area did not qualify as a hydric soil.

The third criterion for wetland determination, i.e., wetland hydrology, is met if there is "permanent or periodic inundation, or soil saturation to the surface, at least seasonally..."(FICWD 1989:7). On poorly to very poorly drained soils, such as occurs in the study area, this wetland hydrology criteria, with regard to saturation, is met if:

1. the water table is less than 0.5 ft from the surface for usually one week or more during the growing season (on mineral soils) or

2. the water table is usually at a depth where saturation to the surface occurs more than rarely (on organic soils) (FICWD 1989:7).

The wetland hydrology criterion for inundation is met if the site is "ponded or frequently flooded with surface water for one week or more during the growing season." (FICWD 1989:7).

The potential classification of most, if not all, of the land in Area A and much of the southern and undeveloped portion of Area B as wetland, as defined by the Manual (FICWD 1989), places severe constraints on the preparation of these areas for development if the development requires land filling. Under present guidelines for delineating jurisdictional wetlands, prior use of a former wetland for agriculture or silvaculture does not affect (i.e., alter) its wetland designation if, under natural conditions, the area would be a wetland. The Texas Wetlands Act (Acts 1989, 71st Leg. Ch 1202) defers to the federal definition in delineating wetlands.

Options for Multiple Use of Areas Remaining within 100-year Ponding Limits

Permit Considerations and Proposed Wetland Impacts

Prevailing policy regarding issuance of a 404 permit for implementation of a land use program which will result in destruction of wetland habitat is that the proposed action must be justified in terms of purpose and water dependency need, and have acceptable mitigation for unavoidable impacts. Prior to issuance of a 404 permit, the permit process must be followed. During this time, the CE must protect the public interest by identifying key concerns and considerations and evaluating the alternatives to the proposed action. This is achieved with preparation of an environmental impact statement (EIS) or environmental assessment (EA) (unless the CE makes a finding of no significant impact), public hearings, and public comment period. In reaching a decision, the CE must follow policies and laws in effect now.

The EPA has veto power over the CE in issuing a 404 permit. Recent comments by one EPA representative (Thomas 1989) summarized EPA's position on wetland destruction. They evaluate a project to determine if there are alternatives to the proposed action which will avoid impact to wetlands. Furthermore, the proposed action must be water dependent. With regard to mitigation, they look for sequencing, i.e., first, avoid impacts; second, minimize impacts by mitigating on site; and third, compensate for unavoidable impacts by mitigating off site.

When mitigating wetland loss, EPA's policy is to recover an acre for each acre lost, including its function. If there is a delay in bringing the replacement acre up to the function of the acre lost, more acreage may be required for mitigation. This is part of their "no net loss" policy which is being defined further. EPA realizes that in coastal areas where there is a prevalence of wetlands, it may be necessary to create wetlands in order to accommodate any development in the future. Furthermore, marsh management to retard or reverse wetland loss is viewed as one alternative to achieving "no net loss."

The major difference between Alternative 1 (Pumping) and Alternative 2 (Pumping and Detention) is that Alternative 2 will remove a larger area from the 100-year ponding limit (3,285 acres versus 1,470 acres). One compelling argument for approval of Alternative 2 is that it would provide flood protection to sites within Area B that are developed. The undeveloped portions of Area B which are under pressure for future development have been degraded already with regard to habitat value because of past flood management practices and weed control or grazing. There would be an economic benefit to the city to have additional sites in Area B developable because of an increased tax base and a decrease in special services that presently result when the developed areas flood.

A portion of Area A also includes some development along State Hwy 365 which would be removed from the 100-year ponding limits under Alternative 2, resulting in economic benefits similar (though less substantial) to those which can be expected in Area B. However, removal of 1,470 (Alternative 1) to 3,285 (Alternative 2) acres from flooding will impact a large area of wetland of varying habitat quality. Future development of some of these reclaimable sites can be expected to require mitigation as a condition of permit approval.

Given the minimal difference in cost and the significant difference in in the area of developed property removed from the 100-year ponding limits, Alternative 2 would be the more economical alternative. However, this is the plan most likely to require the most mitigation because of the larger area of wetland impacted. Mitigation options which would aid approval of the 404 permit for either of these two alternatives are discussed, in general terms, below. More detailed mitigation plans will require additional base line information on environmental, social, economic, and cultural parameters; consultation with all parties involved including city, drainage, and regulatory personnel and private landowners; and detailed information on the drainage system improvements being permitted.

Potential and Mitigating Uses

The value and reason for preserving wetlands is often expressed in terms of their functions (Table A-2). The various wetland areas at this study site presently serve or could be enhanced to serve all of these functions, to some extent, with the exception of Number B: "barriers to waves and erosion." Some of these functions could be enhanced through management for private commercial gain and still retain public benefit functions. For example, improving waterfowl habitat for commercial alligator farming or hunting and trapping leases also improves habitat for other wildlife. Simultaneously, the site continues to function for flood conveyance, flood storage, sediment control, water supply, off season (for hunting and trapping) recreation, education and research, open space and aesthetic values, and water quality enhancement (Table A-2).

Improvement of recreational areas within the wetlands through the construction of nature trails (hiking or canoeing), observation decks (at high quality habitat or aesthetically pleasing sites), fishing ponds, swimming "holes", boating/skiing lakes and canals (using Main Canal "C" and an existing borrow mine), and public access sites, would encourage use of the area by a paying public without significantly altering the quality or function of the wetlands. To make this a commercial venture, additional recreational facilities, such as camp grounds, rental camping units, recreational supply stores, visitor interpreter center or natural history museum-terrarium-aquarium center, small-scale amusement park, may need to be constructed on non-wetland or filled, low quality wetland areas adjacent to the managed wetlands.

A planned, active wetland management program, including water level management, selective planting of vegetation for wildlife food and shelter, and planned landscaping to create permanent standing water areas and "chenier" ridges for upland and migratory species, would increase the

carrying capacity of the habitat and make it even more attractive for tourists. Because this wetland is along a major migratory route, it could be enhanced to attract more migratory birds and wintering ducks and geese. Such an arrangement would not only create resting, shelter, and feeding habitat that is being rapidly lost to erosion and development in other areas of the Strandplain Region of Texas, but it would also attract bird watchers and nature lovers to the area, thus improving and diversifying the local economy.

Acquisition and enhancement of wetlands remaining within the 100-year ponding limits and detention ponds (constructed under Alternative 2) for waterfowl and other wildlife may be acceptable mitigation for a permit allowing for the potential development of reclaimable acreage. Such action could be achieved under the North American Waterfowl Management Plan through a "Joint Venture" between the US Fish and Wildlife Service and the City of Port Arthur and/or private land owners (US Dept. of Interior, Fish and Wildlife Service 1989; LA Dept. of Wildlife and Fisheries et al. 1989, Curtis 1989). Private wetland landowners can benefit from the "Joint Venture" program individually and enhance their wetland for waterfowl or donate land which is to remain within the 100-year ponding limits for conservation in exchange for a permit to develop land reclaimed with Alternative 1 or 2. The ratio of acreage to be donated to compensate for acreage to be impacted by the proposed action would be established by the US Army Corps of Engineers with input from other regulatory agencies such as the US Fish and Wildlife Service, EPA, and Texas Parks and Wildlife Department. The details for funding the management of the donated lands in order to enhance their wetland habitat value and use by waterfowl and other wildlife would have to be developed and the cost included as part of the mitigation requirements.

Construction of the water detention areas could be done in such a way as to improve their wetland value and possibly mitigate, to a limited extent, the potential development of the area removed from the 100-year ponding limits. Details on utilization of the detention ponds for wildlife will be governed by the depth and management of water levels in the pond, i.e., permanently flooded or drained. For example, if the detention ponds are to have permanent standing water, they should be contoured in order to have a shallow shelf which could be planted with submerged aquatics. This shelf area would function as a food and shelter source for aquatic organisms such as fish, shore and wading birds, waterfowl, etc. To prevent growth of undesirable aquatics, it would probably be necessary to dewater the shelf area in the detention ponds periodically. Deeper holes in the ponds would allow fish to survive the dewatering phase. Construction of nesting platforms or an island in the ponds could induce nesting and increase the probability of nesting success for geese and waterfowl . Levees constructed to protect the reclaimable lands could be planted in vegetation to provide food and shelter for upland species. Natural landscaping of the detention pond area with picnic areas and shaded fishing spots would enhance its recreational value as well.

If the detention ponds are to be shallow, dewatered areas, they could be managed as freshwater wetlands if water control structures are installed. To prevent invasion of the site by trees and shrubs which decrease the ponds' flood storage capacity, management would have to include treatment such as burning and/or flooding to kill the shrubby species. The ponds, however, could be planted with waterfowl food and flooded in fall and winter to accommodate migratory ducks and geese. With proper management, it may be possible to lease these areas for cattle grazing. However, care would have to be taken to avoid decreasing the habitat value for other wildlife.

With the growing interest of zoos in using open, yet secured, areas for breeding grounds for threatened or endangered species, some wetland areas which will remain within the 100-year ponding limits may be suitable for wild animal husbandry. Such sites could also be tourist attractions if the animals' safety is guaranteed. Continued use of wetlands for grazing of

Table A-2. Wetlands Functions (The Conservation Foundation 1989).

A. *Flood conveyance*—Riverine wetlands and adjacent floodplain lands often form natural floodways that convey flood waters from upstream to downstream points.

B. *Barriers to waves and erosion*—Coastal wetlands and those inland wetlands adjoining larger lakes and rivers reduce the impact of storm tides and waves before they reach upland areas.

C. *Flood storage*—Inland wetlands may store water during floods and slowly release it to downstream areas, lowering flood peaks.

D. *Sediment control*—Wetlands reduce flood flows and the velocity of flood waters, reducing erosion and causing flood waters to release sediment.

E. *Fish and shellfish*—Wetlands are important spawning and nursery areas and provide sources of nutrients for commercial and recreational fin and shellfish industries, particularly in coastal areas.

F. *Habitat for waterfowl and other wildlife*—Both coastal and inland wetlands provide essential breeding, nesting, feeding, and predator escape habitats for many forms of waterfowl, other birds, mammals, and reptiles.

G. *Habitat for rare and endangered species*—Almost 35 percent of all rare and endangered animal species are either located in wetland areas or are dependent on them, although wetlands constitute only about 5 percent of the nation's lands.

H. *Recreation*—Wetlands serve as recreation sites for fishing, hunting, and observing wildlife.

I. *Water supply*—Wetlands are increasingly important as a source of ground and surface water with the growth of urban centers and dwindling ground and surface water supplies.

J. *Food production*—Because of their high natural productivity, both tidal and inland wetlands have unrealized food production potential for harvesting of marsh vegetation and aquaculture.

K. *Timber production*—Under proper management, forested wetlands are an important source of timber, despite the physical problems of timber removal.

L. *Historic, archaeological values*—Some wetlands are of archaeological interest. Indian settlements were located in coastal and inland wetlands, which served as sources of fish and shellfish.

M. *Education and research*—Tidal, coastal, and inland wetlands provide educational opportunities for nature observation and scientific study.

N. *Open space and aesthetic values*—Both tidal and inland wetlands are areas of great diversity and beauty and provide open space for recreational and visual enjoyment.

O. *Water quality*—Wetlands contribute to improving water quality by removing excess nutrients and many chemical contaminants. They are sometimes used in tertiary treatment of wastewater.

Source: Adapted from Kusler, 1983.

domestic cattle, or new exotic food species, such as water buffalo, may be a profitable use while preserving some of the areas wetland character and function.

The use of the wetlands remaining in Areas A and B for water quality enhancement, after implementation of Alternative 1 or 2, may be of economic value for municipal and industrial communities within the surrounding area which probably will need to meet ever tighter water quality discharge standards in the future. By effectively utilizing some of the wetlands to treat non-point sources of pollution, these users could avoid major capital expenditures for water treatment plants. Fees could be assessed to the surrounding communities to finance management of the wetlands for wastewater treatment. Whether to use the natural wetlands as they exist or to modify portions of the area with minimal infrastructures, such as impoundments, drainage ways, or rock-reed filter systems for treatment, would be determined by the amount and type of pollutants which were targeted for cleanup. For example, water hyacinths growing in linear impoundments have proven to be quite effective in removing municipal pollutants in cities as large as San Diego. They are most effective when they can be placed in large areas adjacent to municipalities with a mild climate, as in this area.

The basic functions of wetlands which make them suitable for wastewater treatment are:

1. Dispersion of surface waters over a large area through intricate channelization of flow.

2. Physical entrapment of pollutants through sorption in the surface soils and organic litter.

3. Uptake and metabolic utilization of plants.

4. Utilization and transformation of elements by microorganisms (Chan et al. 1981).

Wetlands have been used to treat municipal and industrial wastewaters, stormwater runoff, and agricultural return flows in order to remove a variety of materials such as high organic and nutrient loads, suspended solids, salts and pesticide residues (Hantzsche 1985). However, it is essential that pilot studies be conducted for the area proposed for use prior to major implementation. A possible source for funding the pilot study is the Environmental Protection Agency. Furthermore, incorporation of this use into the multiple use plan for improving the Alligator Bayou drainage system would help justify the proposed action (i.e., Alternative 1 or 2) in terms of water dependency.

The growing demand for wetland plants to be used for wetland restoration or stabilization programs in the Gulf Coast Region is another potential commercial use for the wetland and transitional areas in this floodplain. Growing wetland plants would preserve most of the normal wetland functions while providing a renewable resource. The wetland plants could be emergent vegetation, such as cutgrass and cordgrass, or tree seedlings, such as cypress (Taxodium distichum) and tupelogum (Nyssa spp.).

Commercial production of flood tolerant trees, such as cypress, cottonwood (Populus deltoides) and willow is another potential use for portions of the floodplain. Extraction of this renewable resource would have minimal impact on wetland function and relatively temporary impact on native wildlife.

Conclusions

These multiple use options have been presented in general terms but they represent just some of the feasible uses of wetlands for commercial and mitigation purposes. Some of these uses can

be undertaken by private landowners now if they wish to have an economic return on their property. Other uses which involve filling of wetlands will require 404 permits. Close coordination and cooperation among private property owners, City officials, Drainage District officials, and Regulatory Agency personnel during the 404 permit review of the proposed action for improving the Alligator Bayou Drainage System will be needed in order to create a workable, multiple use program which will protect the public interest as well as private property rights.

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EXHIBIT A-3

TEXAS
PARKS AND WILDLIFE DEPARTMENT
4200 Smith School Road Austin, Texas 78744

CHARLES D. TRAVIS
Executive Director

October 6, 1989

Karen M. Wicker, Ph.D.
Director, Applied Science Division
Coastal Environments, Inc.
1260 Main Street
Baton Rouge, Louisiana 70802

Dear Dr. Wicker:

In response to your October 3, 1989 request for information on sensitive species and natural communities within or near the proposed drainage system improvements within Drainage District No. 7, Jefferson County, Texas, we offer the following comments. A search of the Texas Natural Heritage Program Information System revealed no presently known occurrences of special species or natural communities in the general vicinity of the project.

The Heritage Program information included here is based on the best data currently available to the state regarding threatened, endangered, or otherwise sensitive species. However, these data do not provide a definite statement as to the presence or absence of special species or natural communities within your project area, nor can these data substitute for an evaluation by qualified biologists. This information is intended to assist you in avoiding harm to species that occur on your site.

This letter does not constitute an assessment of fish and wildlife impacts that might result from the activity for which this information is provided. Should you need an impact assessment from the Texas Parks and Wildlife Department, contact the Environmental Assessment Branch of the Resource Protection Division, attention Mr. Bob Spain, or contact him at 512/389-4725. All requests for assessments must be in writing.

Please contact the Texas Parks and Wildlife Department's Heritage Program before publishing or otherwise disseminating any specific locality information. Thank you for contacting us. Please feel free to call me at 512/389-4533 if you have questions.

Sincerely,

Dorinda Sullivan

Dorinda Sullivan, Data Manager
Texas Natural Heritage Program
Resource Protection Division

EXHIBIT A-4

TEXAS ANTIQUITIES COMMITTEE

P.O. Box 12276 Austin, Texas 78711 (512) 463-6098

October 13, 1989

Karen M. Wicker, Ph.D.
Applied Science Division
Coastal Environments, Inc.
1260 Main St.
Baton Rouge, LA 70802

RE: Port Arthur Drainage District #7

Dear Dr. Wicker:

In general the area indicated on the map you sent us has no previously recorded archeological sites or historic structures. But without more detailed project specific information; i.e., plottings of the exact route of the proposed drainage system in question, it would be impossible for us to seriously review this project and potentially clear any of it for development.

When available, please send us the exact routes plotted on a copy of a 7.5 minute USGS Quadrangle Map.

Sincerely yours,

Mark H. Denton

Mark H. Denton
Staff Archeologist

MHD:dml

ALLIGATOR BAYOU PONDING STUDY
PORT ARTHUR, TEXAS

APPENDIX B
LAND USE STUDY

KERRY R. GILBERT & ASSOCIATES, INC.

I. Introduction and Purpose of Study

The purpose of this study was to prepare a land use plan reflecting the determinations and recommendations made in the engineering portion of the report.

Two alternatives were investigated from an engineering perspective with each reclaiming a portion of the existing 100 year ponding limits and thereby creating the potential for future development. Due to the exorbitant cost, limited accessibility, and minimal amount of reclaimed property, Alternate One was not considered viable. Instead, Alternate Two which would reclaim more than 3200 acres and allow for phased implementation was recommended as the most advantageous.

With the study area defined as a result of the engineering conclusions, a land use analysis was performed which addressed the future needs of the study area in concert with existing development and goals for the overall area established in the City of Port Arthur's Comprehensive Plan. Potential land use, traffic corridors, and community facilities were considered in preparing the land use plan. The plan, which is illustrated on a map of the study area and included with this study, should be considered conceptual in nature and utilized as a guide for determining project phasing and cost effectiveness. The plan assumes ultimate growth of the study area and is not associated with a specific time frame.

II. Study Area

As previously mentioned in the engineering portion of the study, the Alligator Bayou watershed is located in southern Jefferson County and includes property in northern Port Arthur and neighboring cities. Drainage for the area is provided by three large drainage canals, referred to as Main "A", "B", and "C". Due to the relatively low elevations in the lower portion of the watershed where these drainage canals converge, a significant amount of ponding has occurred and the property has remained undeveloped. It is this portion of the watershed that is the subject of this study and for which the following land use plan is prepared. The study area includes the property situated between Jefferson County Airport to the north, State Highway 73 to the south, State Highway 347 to the east and West Port Arthur Road to the west. For planning and reference purposes, the study area was divided into the following sectors:

Sector A: The land situated between Jefferson County Airport to the north, State Highway 73 to the south, U.S. Highway 69 to the east, and West Port Arthur Road to the west.

Sector B: All land between State Highway 365 to the north, State Highway 73 to the south, State Highway 347 to the east, and U.S. Highway 69 to the west.

III. Existing Conditions

For the most part, the study area is currently undeveloped with more than 5500 acres of vacant property. The development that does exist is among the newest in the Port Arthur area and ranges from large scale mixed use to small scattered individual uses.

Most of the residential development, both single-family and multi-family, is concentrated in the northern portion of Sector B near State Highway 365 and 9th Avenue and are part of the Stonegate Subdivision development. Various retail/commercial developments are located along the frontage of the major traffic corridors within the study area, culminating with Central Mall at the southeastern junction of State Highway 365 and U. S. Highway 69. Assorted institutional and government facilities including churches, schools and parks, are located within the study area, primarily within Sector B. Major public facilities include the Babe Zaharias Golf Course and the City of Port Arthur's Civic Center which is situated along State Highway 73. Industrial uses are confined to the Jefferson County Airport vicinity in Sector A, north of State Highway 365 with the exception of a lone industrial site located just east of the Jefferson County Drainage District # 7's (J.C.D.D.#7) detention pond in the southwest quadrant of Sector B.

The following regional thoroughfares have an impact on the study area and are all a part of the regional highway plan.

1.) State Highway 73 - This thoroughfare is being developed as a strong east-west freeway across southern Jefferson County area serving Port Arthur and adjacent communities. State Highway 73 serves as an important connection between Interstate 10 and the City of Orange.

2.) U.S. Highway 69 - The most direct connection to the City of Beaumont, Highway 69 will be developed as a full freeway north of State Highway 73 with landscaping and a provision for frontage roads to create a significant entry route into Port Arthur from the Jefferson County Airport.

3.) State Highway 347 - Currently acts as supplemental north-south access route to State Highway 69 and will likely become a major traffic carrier as development in the area continues.

4.) State Highway 365 - Currently being developed as a four lane expressway with limited cross street access between State Highway 347 and U.S. Highway 69.

5.) 9th Avenue - This thoroughfare exists as a two lane roadway and currently serves as a minor collector street within Sector B.

IV. Land Use Plan

Due to the conceptual nature of this study, eight basic land use categories were utilized to formulate the land use plan. The land use categories include single-family residential, multi-family residential, mixed use, retail commercial, institutional/government, light industrial/business park, industrial and parks/open space.

The single-family, multi-family, retail-commercial and parks/open space categories are self-explanatory while other land use categories were either grouped or divided and require further definition. The institutional/government category includes churches and fraternal organizations, schools and all local, state and federal government facilities. The industrial category was sub-divided to make a distinction between heavy manufacturing and production and light manufacturing and distribution (i.e., office/warehouse type facilities). The mixed-use category was utilized for those properties whose size and location are such that they may be developed into a number of uses and are likely to be influenced by the growth patterns of the surrounding area. Ultimate uses for these sites generally include all of the above defined uses with the exception of industrial. A summary of the proposed land use distribution can be found on the Land Use Distribution Chart included within this study.

SECTOR A

In general, the bulk of Sector A remains a part of the 100 year ponding area and is labeled as vacant on the accompanying map of the land use plan. The environmental analysis associated with this study (see appendix A) discusses potential uses for this area that are compatible with its natural characteristics.

The area that would be reclaimed in Sector A is concentrated near the intersection and along the frontage of State Highway 365 and U.S. Highway 69 and consists of approximately 750 acres. Development of this area will be heavily influenced by these two major highways and the Jefferson County Airport.

The area north of State Highway 365 is planned primarily for industrial and light industrial/business park development due to its proximity to the Jefferson County Airport. Approximately 520 acres are available for these uses in this vicinity. In addition, an appropriate amount of retail development (approximately 83 acres) is projected along the frontage of State Highway 365 and U.S. Highway 69.

The reclaimed area in Sector A, south of State Highway 365, is planned for mixed uses, including multi-family, retail development and industrial. More than 300 acres will be made available for development in this area which will be influenced by the ultimate plans for the large vacant tract in addition to the major highways and the Jefferson County Airport. No single-family development is proposed in Sector A.

The proposed 275 acre detention facility is also located in this area, intercepting and detaining storm water runoff from the upper reaches of Main "C".

An alternative land use plan which was considered for Sector A involved the relocation of the proposed detention facility to the area north of State Highway 365 in the vicinity of the Jefferson County Airport. This, coupled with the proposed instrument landing system (ILS) runway for the Jefferson County Airport would significantly alter the potential uses south of State Highway 365. The proposed ILS runway will divert aircraft approaches from directly over the Alligator Bayou Ponding area to the west along a boundary between the Port Acres area and other vacant property. The increase in the amount of property south of State Highway 365 and the significant reduction in aircraft noise would make the area more conducive to single-family development. This alternate land use plan is illustrated on Exhibit B-2 and referred to as Land Use Plan 1A.

SECTOR B

The conceptual land use plan for Sector B calls for the expansion of the single-family residential development which has occurred in the northern portion of the sector. In general, the residential cells would revolve around the intersection of 9th Avenue and 60th Street, two of the primary collector streets which currently serve the interior of Sector B. It is anticipated that these two internal collectors would be developed as parkways, providing access to the residential cells and the various attendant service facilities that accompany concentrations of single-family development. This concept will require the dedication of additional right-of-way for esplanade and adjacent landscape treatment, but will allow these corridors to become attractive internal ribbons complementing the parks and greenbelt system (discussed later in this section) and connecting the residential area with the surrounding major retail facilities and the Port Arthur Civic Center complex. These two scenic parkways will aid in providing the area with a common neighborhood development theme and promote community cohesiveness.

In all, more than 900 acres are designated for single-family development within Sector B. The development of these cells will be accompanied by the usual service facilities that are common to and compatible with single-family neighborhoods. Although no additional institutional/government cells were specifically illustrated in the proposed land use plan, it is anticipated that the large single-family cells will accommodate schools, churches, and recreational facilities which will be strategically located throughout the Sector. Internal retail uses should be reserved for small service centers containing convenience stores, dry cleaners, small fitness centers, clinics, child care and other similar residential support facilities.

The development of a integrated parks and open space system within Sector B will be of paramount importance to the success of the development of Sector B and the study area as a whole. The Babe Zaharias Golf Course and Adams Park provide the basis for a comprehensive park system for the study area. The various pipeline easements and utility corridors located throughout Sector B could easily be incorporated into the greenbelt system. These corridors coupled with the unique opportunity presented by Main Canals "A" and "B" for recreational use provide Sector B with an intricate greenbelt system that serves virtually every developable cell. Other parks and open space proposals for Sector B include tract of land approximately 20 acres in size on 60th Street near Adams Park, a 60 acre site located between Main Canal "A" and the Gulf States Utilities easement in the eastern

portion of Sector B, a 121 acre site situated between 9th Street, Main Canal B, and the Gulf States Utilities easement, and a 128 acre site located at the corner of State Highway 73 and U.S. Highway 69. The size and location of each of these areas is attributable to the various existing physical conditions including lakes and ponds that are prevalent in the vicinity. In all, more than 800 acres, or 24% of the property within Sector B, is allocated for parks and open space. This includes the existing J.C.D.D. # 7's detention pond, and the proposed 110 acre detention facility which is located between Main Canal "A" and the K.C.S. Railroad in the southeastern quadrant of Sector B. This location, when coupled with the adjacent existing J.C.D.D. # 7's detention pond, provides a satisfactory buffer between the single-family cells and the land uses proposed in the vicinity of State Highway 347 and State Highway 73.

The balance of the proposed development within Sector B is concentrated along the major highways and consist primarily of retail and mixed use development. These sites tend to be large in size in order to accommodate larger scale developments that desire the convenient access and high visibility afforded by the large traffic volumes along the major highways. Mixed use and retail account for 19% of the total acreage within Sector B.

The only industrial cell proposed in Sector B is located in the southeastern quadrant. The boundary of this cell was enlarged from the existing industrial site because of its existing rail access and the fact that it is sufficiently buffered from the single-family calls. Industrial use, including light industrial/business parks account for 7%, or approximately 200 acres, of the total development within Sector B.

ALLIGATOR BAYOU PONDING STUDY

LAND USE DISTRIBUTION

Land Use Study	Sector A (acres)	%	Sector B (acres)	%	Study Area (acres)	Total %
Family	0.0	0.0	906.0	31.0	906.0	12.0
Multi-Family	57.0	1.0	209.0	7.0	266.0	3.0
Mixed-Use	45.0	1.0	149.0	5.0	194.0	2.0
Retail-Commercial	153.0	3.0	440.0	15.0	593.0	8.0
Institutional/Government	5.0	1.0*	166.0	6.0	171.0	2.0
Lt. Industrial/ Business Park	185.0	4.0	53.0	2.0	238.0	4.0
Industrial	402.0	9.0	147.0	5.0	549.0	7.0
Park/Open Space	3,978.0	82.0	823.0	29.0	4,803.0	62.0
TOTAL	**4,825.0**	100.0	2,895.0	100.0	7,720.0	100.0

* = less than 1%

Land Use Category	Sector 1A (acres)	%	Sector B (acres)	%	Study Area (acres)	Total %
Single-Family	383.0	8.0	906.0	31.0	1,289.0	17.0
Multi-Family	0.0	0.0	209.0	7.0	209.0	3.0
Mixed-Use	149.0	4.0	149.0	4.0	298.0	4.0
Retail-Commercial	126.0	3.0	440.0	15.0	566.0	7.0
Institutional/Government	5.0	1.0*	166.0	6.0	171.0	2.0
Lt. Industrial/ Business Park	329.0	7.0	53.0	2.0	382.0	5.0
Industrial	40.0	1.0*	147.0	5.0	187.0	2.0
Park/Open Space	3,793.0	78.0	823.0	29.0	4,616.0	60.0
TOTAL	4,825.0	100.0	2,895.0	100.0	7,720.0	100.0

* = less than 1%

Note: All acreages indicated are estimates.

APPENDIX C

ALLIGATOR BAYOU DRAINAGE STUDY

For The

CITY OF PORT ARTHUR

JEFFERSON COUNTY

DRAINAGE DISTRICT # 7

SOUTEX SURVEYOR'S, INC.

Study Dates
September 1 - 30, 1988

Soutex Surveyors, Inc. recovered five bench marks from a U.S.G.S. second order system along the Southern Pacific Railroad near the West Port Arthur Road. One of the five bench marks, U.S.G.S. H-1016, was used as the reference monument; T.C.& B.'s 1980 elevation of 5.512 was the reference elevation. Three wire level loops were run between H-1016 and J-1016, H-1016 and G-1016, and also G-1016 and F-1016. The results of the survey were as follows:

Monument	T.C.& B.1980 Elev.	1988 Elev.	Remarks
H-1016	5.512	5.512	
J-1016	9.999	10.0736	+0.0786
G-1016	3.221	3.2820	+0.061
F-1016	2.857	2.8987	+0.0417

The survey indicated that reference monument H-1016's elevation of 5.512 had changed. The elevation of monuments J-1016, G-1016, and F-1016, were within the limits of one to two hundredths of a foot. Therefore, monument G-1016 was selected as the reference monument with an elevation of 3.221 for the remainder of the survey in checking the Williams-Stackhouse survey of 1976 and the T.C. & B. survey of 1980.

A three wire level run was made from G-1016 east along FM Hwy. 365 to U.S. Hwy. 69, thence south along U.S. Hwy. 69 to 60th Street, thence east along 60th Street to Williams-Stackhouse monument and TBM's as well as D.D.No. 7 bench mark "D.D. Yellow". The results of this run are shown in the attached Exhibit "A" and indicate about two-tenths (0.2) lower elevations than in the Williams-Stackhouse survey. A sideshot on J.C.D.D. No. 7 bench mark "D.D. Yellow" at Main "C" Canal structure on FM 365 revealed an elevation of 3.834. The survey of Williams-Stackhouse (1976) shows an elevation of 4.03 instead of 4.74, the elevation used by J.C.D.D. No. 7. It was decided to run a level

check between G-1016 to J.C.D.D. No. 7 bench mark "D.D. Yellow". The level run showed a difference of only 0.03 feet.

A three wire run was then made from bench mark "D.D. Yellow" south on Main "C" Canal to Williams-Stackhouse monument No. 10. The present elevation of monument 10 was found to be 3.212 compared to the 1976 elevation of 3.76.

At this time it was decided to support to use monument G-1016 as the reference monument. A three and one-half mile three wire run was established on the West Port Arthur Road between J-1016 and P-1016. Elevation of P-1016 on this run was 16.648 compared to the T.C. & B. 1980 elevation of 16.645. This satisfied Soutex Surveyors, Inc. that G-1016 was a good reference monument.

The staff of Soutex Surveyor's, Inc. studied all of the field data and made a decision to run the primary vertical control South along the Southern Pacific Railroad tracks and to tie one or more bench marks utilized by J.C.D.D. No. 7. A level run was made between T.C. & B.'s T.B.M-T22 to USCE monument C-26.

During the above run, ties were also made to T.B.M.-T23, S-1015, L-1016, V-57, and D.D. No. 7 bench mark on a concrete wall where the storm protection levee crosses State Hwy. 87. A side run was made to the floor slab of J.C.D.D. No. 7 pump station No. 16. The floor elevation was found to be 16.218, compared to the J.C.D.D. No. 7 elevation of 17.00. The USCE elevation of 16.41 in 1986 was reported from a telephone conversation between Lee Ganna with the C.O.E. (Galveston Office) and Jim Trahan with J.C.D.D. No. 7 (See Exhibit "C".) It appears that there may have been a possible elevation correction of USCE monuments in this area between the initial construction of the storm protection levee and before the final construction phase.

The survey revealed that the vertical control used by the City of Port Arthur (T.C. & B. 1980) shows a difference of approximately 0.78 from that used by J.C.D.D. No. 7. The vertical data used in the design of the Stonegate Manor area by T.C. & B. 1969 and the vertical control used by T. C. & B. 1980 were also checked using bench mark No. 10, located on the rim of a S.W.B.T. Company manhole cover near the old entrance of Wallings Dairy on FM Hwy. 365. The vertical control used by T.C. & B. 1980 shows that the true elevation should be 9.50 instead of 10.23 (T.C. & B. 1969). The difference of 0.73 is approximately the same difference that exists between the surveys of J.C.D.D. No. 7 and the City of Port Arthur (T.C. & B. 1980).

CONCLUSION

The present field survey has revealed that all agencies are not using the same vertical network. To meet the requirements of the Federal Emergency Management Agency and others, this practice cannot continue. The City of Port Arthur, J.C.D.D. No. 7 and other local agencies should establish a system of bench marks, and all vertical work should originate from this system. No exceptions should be allowed. Differences in the existing vertical networks should not continue to be ignored.

SOUTEX SURVEYORS, INC.

3727 Doctors Drive • Port Arthur, Texas 77642

409/983-2004

CITY OF PORT ARTHUR - DRAINAGE DISTRICT NO. 7

TABULATION OF ELEVATIONS

Exhibit "A" -

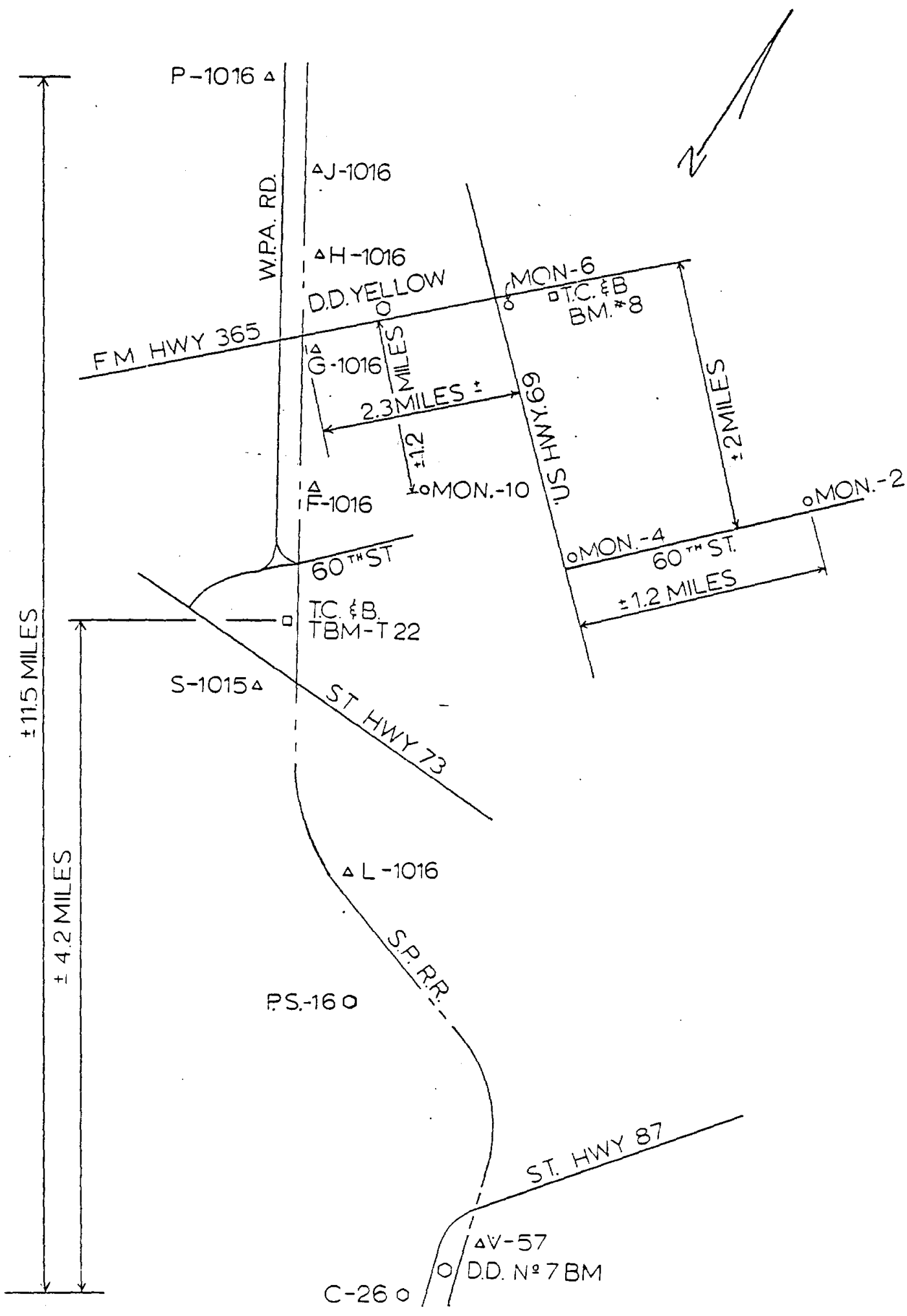
Bench Mark	Williams-Stackhouse 1976	T.C. & B. 1980	D.D. No. 7 and or USCE	Soutex 1988	Remarks
	Elev. Ft.	Elev. Ft.	Elev. Ft.		Elev. Ft.
G1016	3.42	3.221		3.221	Re. Benc Mark
F 1016	3.09	2.857		2.838	
H 1016	5.73	5.512		5.451	
J 1016	10.15	9.999		10.013	
T.B.M.-3	2.80			2.654	
D.D. Yellow	4.03		4.74	3.864	D.D. No.
Mon.-6	26.12			25.851	
Mon.-4	1.77			1.571	
Mon.-2	5.30			5.186	
Mon.-10	3.76			3.212	
P 1016		16.645		16.648	
T.B.M.-8	4.18			4.033	
T.B.M.-9	7.68			6.544	
T.B.M. T-22		6.532		6.486	
B.M. No. 8		7.725		6.824	T. C. & 1969
C-15		1.090		1.064	
C-16		1.654		1.571	
C-14		5.457		5.371	
D-35		2.617		2.521	
D-29		2.487		2.314	
D-28		1.859		1.719	
D-8		2.923		3.338	
D-1		-0.208		-0.157	
C-27		1.984		1.966	
C-28		2.813		2.871	
C-29		1.246		1.304	
C-26		1.929		1.921	
C-25		0.027		0.041	
S-1015			5.849	5.736	USCE 19
T.B.M.-T.-23		6.699		7.036	
L-1016		8.861		8.883	
V-57		9.340	9.379	9.409	USCE 19

Bench Mark	Williams-Stackhouse 1976	T.C. & B. 1980	D.D. No. 7 and or USCE	Soutex 1988	Remark:
	Elev. Ft.	Elev. Ft.	Elev. Ft.		Elev. Ft
P.S.-16			16.41	16.218	USCE 19
P.S.-16			17.00		D.D. No
P.S.-16					
Tidegauge			4.00	3.248	D.D. No
B.M.			14.70	14.179	D.D. No
C-26			8.18	7.804	USCE 19
C-23		1.203		1.1595	
BM-10		10.23		9.4958	TC&B 19
*BM-5		8.56		7.8442	
*BM-6		8.74		8.0142	
*BM-8		7.47		6.7442	
*BM-9		6.96		6.2292	
C-6		3.575		3.5742	
C-17		-0.296		-0.3357	
C-22		0.250		0.2062	
C-21		-0.121		-0.1788	
C-20		-0.315		-0.3855	
C-19		0.317		0.2544	
C-5		5.183		5.156	
C-11		1.085		1.074	
C-8		3.835		3.823	

* These bench marks were not set by T.C. & B., but are references from T.C. & B.'s BM-10 in 1974. The bench marks were established on top of G.S.U.'s anchor bolts. The G.S.U. K.V. line runs south of FM Hwy. 365 along the east side of the Stonegate area.

Williams-Stackhouse Monuments Not Recovered

Mon.-1 Destroyed
Mon.-3 No Evidence of Monument
Mon.-5 No Evidence of Monument
Mon.-7 Destroyed
Mon.-8 No Evidence of Monument
Mon.-9 Destroyed
Mon.-11 No Evidence of Monument
Mon.-12 Top and Cap Broken Off


P-1016
J-1016
W.P.A. RD.
H-1016
D.D. YELLOW
MON-6
T.C. & B
BM. #8
FM HWY 365
G-1016
1 MILES
2.3 MILES ±
±1.2
MON.-10
US HWY 69
±2 MILES
MON.-2
F-1016
MON.-4
60TH ST
60TH ST.
±1.2 MILES
T.C. & B.
TBM-T 22
S-1015
ST HWY 73
±11.5 MILES
±4.2 MILES
L-1016
S.P.R.R.
P.S.-16
ST. HWY 87
V-57
D.D. Nº 7 BM
C-26

Memo To File

Telephone Conversation

DATE 9/27/88 TIME _____ BY JCT

COMPANY C.O.E. - GALV.

TALKED WITH LEE GANNA

PHONE NO. 1-766-3180

PROJECT

	'54	'59	'70	'75
S 1015	6.549	6.506	6.050	5.849

V-57 (IN 1973) 9.379

ALLIGATOR P.S. IN 1986 from a Loop using F2 & F4

EL. 16.41

V-57.	'18	'54	'59	'70	'75
	9.957	9.678	9.633	9.534	9.379

F2 (IN 1978) 5.39

F4. (IN 1978) - 3.25 // (IN 1988) - 3.19.

HYDROLOGIC & HYDRAULIC MODELS
(Separate Cover)

FILE	DESCRIPTION
APPENDIX D	
EXISTING CONDITIONS	
ALLIG1.H1	HEC-1 Analysis of Alligator Bayou Watershed
STOROUT.H2	HEC-2 Storage Analysis of Main Outfall Channel
STORA.H2	HEC-2 Storage Analysis of Main "A"
STORC.H2	HEC-2 Storage Analysis of Main "C"
ALLIGPUM.XIS	Pump Routing Analysis of Alligator Bayou Pump Station
ALLIGPUM.OUT	Output File Listing for ALLIGPUM.XIS
MAINOUT.STO	HEC-2 Level Pool Storage Analysis of Main Outfall Channel
MAINOUT.HL1	HEC-2 Head Loss Analysis of Main Outfall Channel, Flow = 1000 cfs
MAINOUT.HL2	HEC-2 Head Loss Analysis of Main Outfall Channel, Flow = 2000 cfs
MAINOUT.HL3	HEC-2 Head Loss Analysis of Main Outfall Channel, Flow = 3000 cfs
MAINOUT.HL4	HEC-2 Head Loss Analysis of Main Outfall Channel, Flow = 4000 cfs
MAINOUT.HL5	HEC-2 Head Loss Analysis of Main Outfall Channel, Flow = 5000 cfs
MAINA.H2	HEC-2 Analysis of Main "A"
MAINB.H2	HEC-2 Analysis of Main "B"
MAINC.H2	HEC-2 Analysis of Main "C"
APPENDIX E	
PROPOSED ALTERNATIVE 1	
ALLIGPUM.8P	Pump Routing Analysis of Alligator Bayou Pump Station - 8 Pumps
ALLIGPUM.OUT	Output File Listing for ALLIGPUM.8P
MAINOUT.HL6	HEC-2 Head Loss Analysis of Main Outfall Channel, Flow = 6000 cfs
MAINOUT.HL7	HEC-2 Head Loss Analysis of Main Outfall Channel, Flow = 7000 cfs
MAINOUT.HL8	HEC-2 Head Loss Analysis of Main Outfall Channel, Flow = 8000 cfs
MAINOUT.HL9	HEC-2 Head Loss Analysis of Main Outfall Channel, Flow = 9000 cfs
MAINOUT.HL0	HEC-2 Head Loss Analysis of Main Outfall Channel, Flow = 10,000 cfs
MAINA8P.H2	HEC-2 Analysis of Main "A" - Starting WSEL for 8 Pumps
MAINB8P.H2	HEC-2 Analysis of Main "B" - Starting WSEL for 8 Pumps
MAINC8P.H2	HEC-2 Analysis of Main "C" - Starting WSEL for 8 Pumps
APPENDIX F	
PROPOSED ALTERNATIVE 2	
ALLIG2PR.H1	HEC-1 Analysis of Alligator Bayou Watershed - Proposed Routings & Improvements
ALLIGPUM.PRO	Pump Routing Analysis of Alligator Bayou Pump Station - Existing Station - Proposed Routings & Improvements
ALLIGPUM.OUT	Output File Listing for ALLIGPUM.PRO
MAINALPR.H2	HEC-2 Analysis of Lower Main "A" - Proposed Routings & Improvements
MAINAUPR.H2	HEC-2 Analysis of Upper Main "A" - Proposed Routings & Improvements
MAINBCI.H2	HEC-2 Analysis of Main "B" - Proposed Routings & Improvements
MAINCLPR.H2	HEC-2 Analysis of Lower Main "C" - Proposed Routings & Improvements
MAINCUPR.H2	HEC-2 Analysis of Upper Main "C" - Proposed Routings & Improvements

Alligator Bayou Ponding Study Port Arthur, Texas
Contract No. 8-483-633

The following maps are not attached to this report. They are located in the official file and may be copied upon request.

Existing Drainage Area Map - Job No. 467-05 Exhibit 2

Cross Section Layout - Job No. 467-05 Exhibit 3

Existing 100-yr. Ponding Limits & Proposed Alternative 1 Ponding Limits Job 467-05 Exhibit 4

Proposed Drainage Area Map Alternative 2 Job No. 467-05 Exhibit 5
Existing 100-Yr Ponding Limits & Proposed Alternative 2 Ponding Limits Job 467-05 Exhibit 6

Soil Phase Job 88-32 Exhibit A-1

Generalized Habitat Map Job 88-32 Exhibit A-2

Proposed Land Use 1 For Reclaimed Area Alternate 2 Exhibit B-1
Proposed Land Use 1A for relaimed area alternate 2 Exhibit B-2
Please contact Research and Planning Fund Grants Management Division at (512) 463-7926 for copies.